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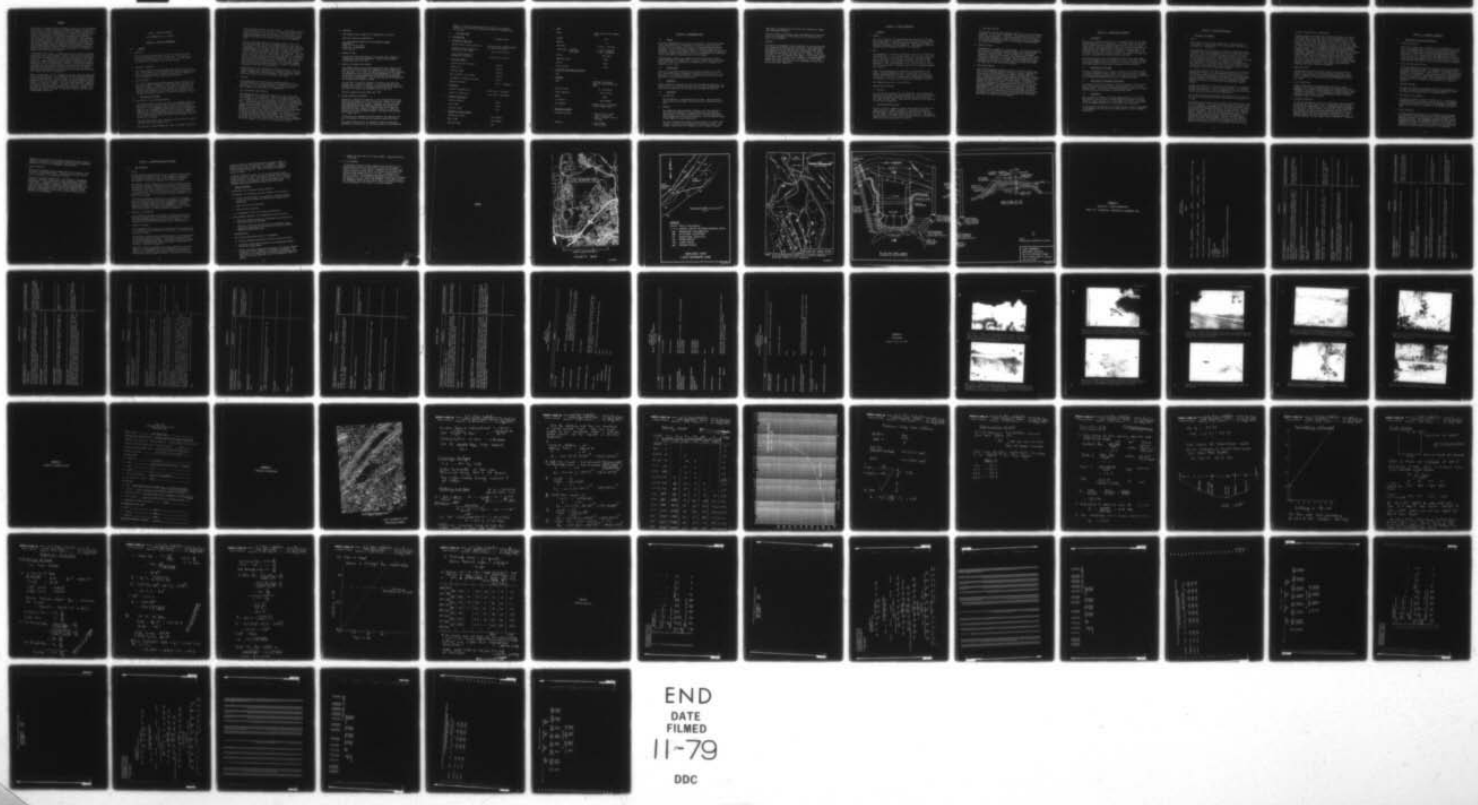

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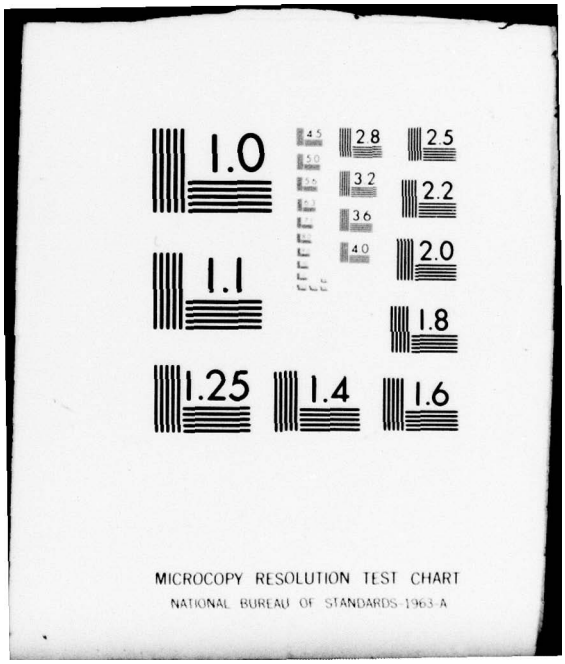
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PASSAIC RIVER BASIN
GREEN POND BROOK, MORRIS COUNTY
NEW JERSEY

LEVEL II

LAKE DENMARK DAM
NJ 00001

(6) PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

Lake Denmark Dam (NJ-00001). Passaic River Basin. Green Pond Brook, Morris County, New Jersey. Phase 1 Inspection Report.

(15) DACW61-79-C-0011

(10) Anthony G. /Posch

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DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

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REPORT DOCUMENTATION PAGE

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Lake Denmark Dam
Spillways
Seepage
Dams
Visual Inspection
Structural Analysis
National Dam Inspection Act Report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE - 2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-D

SUBJECT: Dam Inspection Program

27 SEP 1979

Commander
U.S. Army Armanent Research and Development Command
DRDAR - PSE - CF
Dover, New Jersey 07801

1. Inclosed is the Phase I Inspection Report for Lake Denmark Dam, Picatinny Arsenal, Morris County, New Jersey which has been prepared for the U.S. Army Engineer District, Philadelphia. A brief assessment of the dam's condition is given in the front of the report.

2. Based on visual inspection, available records, calculations and past operational performance, Lake Denmark Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate since 23 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within twelve months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of observation wells or piezometers to facilitate seepage studies. Any remedial measures found necessary should be initiated within calendar year 1980.

c. A complete topographic survey of the dam area should be made within twelve months from the date of approval of this report, in order to develop a detailed plan and several cross-sections of the dam. The location of utilities on the dam should be shown in the drawings, and any benchmarks shown. The headwater gage datum should be checked during the survey. Annotate and update the existing drawings to form a coherent as-built set.

d. The following remedial actions should be completed within one year from the date of approval of this report:

(1) Remove all debris blocking the downstream road culverts and the channel above the culverts.

(2) Remove all trees from the dam crest and downstream slope, from the spillway area and from above the culvert structure. Regrade the downstream slope.

(3) Study the need for additional low-level outlet facilities. If found necessary, initiate installation within calendar year 1980.

(4) Review the present operational procedures, and develop specific guidelines on valve operation and emergency procedures. The guidelines, to be agreed upon by upstream and downstream users and by all parties concerned, should then be implemented.

(5) Remove the fish trap if no longer needed. Otherwise provide a new trap.

e. A formalized program of annual inspection of the dam should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read out during severe rain storms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam and the lake. The downstream embankment face should be checked for seepage at routine visits, and movement or settlement of the dam embankment should be monitored by means of surveying monuments and by measurement of the cracks in the road pavement.

NAPEN-D
SUBJECT: Dam Inspection Program

3. Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia, 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

4. An important aspect of the Dam Safety Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken to implement our recommendations.

1 Incl
As stated

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

Copies Furnished (trip)
U.S. Army Armanent Research and Development Command
DRDAR - PSE - E
Dover, New Jersey 07801
Attention: C. Berkowitz

LAKE DENMARK DAM (NJ00001)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 12 July 1979 by Frederic R. Harris, Inc. for the U.S. Army Engineer District, Philadelphia.

Lake Denmark Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate since 23 percent of the Spillway Design Flood--SDF - would overtop the dam. (The SDF, in this instance, is the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To insure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant using more sophisticated methods, procedures, and studies within six months from the date of approval of this report. Any remedial measures necessary to insure the adequacy of the spillway and to prevent overtopping should be initiated within calendar year 1980. In the interim, a detailed emergency operation plan and warning system should be promptly developed. Also, during periods of unusually heavy precipitation, around-the-clock surveillance should be provided.

b. Within twelve months from the date of approval of this report, engineering studies and analyses should be performed to determine the dam's embankment and foundation condition and structural stability. This should include test borings to determine material properties relative to stability and seepage and installation of observation wells or piezometers to facilitate seepage studies. Any remedial measures found necessary should be initiated within calendar year 1980.

c. A complete topographic survey of the dam area should be made within twelve months from the date of approval of this report, in order to develop a detailed plan and several cross-sections of the dam. The location of utilities on the dam should be shown in the drawings, and any benchmarks shown. The headwater gage datum should be checked during the survey. Annotate and update the existing drawings to form a coherent as-built set.

d. The following remedial actions should be completed within one year from the date of approval of this report:

(1) Remove all debris blocking the downstream road culverts and the channel above the culverts.

(2) Remove all trees from the dam crest and downstream slope, from the spillway area and from above the culvert structure. Regrade the downstream slope.

(3) Study the need for additional low-level outlet facilities. If found necessary, initiate installation within calendar year 1980.

(4) Review the present operational procedures, and develop specific guidelines on valve operation and emergency procedures. The guidelines, to be agreed upon by upstream and downstream users and by all parties concerned, should then be implemented.

(5) Remove the fish trap if no longer needed. Otherwise provide a new trap.

e. A formalized program of annual inspection of the dam should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read out during severe rain storms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam and the lake. The downstream embankment face should be checked for seepage at routine visits, and movement or settlement of the dam embankment should be monitored by means of surveying monuments and by measurement of the cracks in the road pavement.

APPROVED: James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

DATE: 26 Sep 79

PHASE I INSPECTION REPORT

Name of Dam: Lake Denmark, I.D. NJ00001

State Located: New Jersey

County Located: Morris County

Stream: Burnt Meadow Brook

Date of Inspection: July 12, 1979

Assessment of General Condition

Lake Denmark Dam is an earth and rock fill embankment approximately 360 feet long and 12 feet high. The right side of the embankment contains an unregulated concrete-surfaced spillway which is 30 feet long. Bedrock outcrops in the center of the dam. Lake Denmark Dam is in good overall condition. There is no major sign of distress or instability of the embankments, although minor surface cracks were noted in the road pavement. Low-level sluices are all operable. The hazard potential is rated as "high."

The adequacy of Lake Denmark Dam is considered questionable in view of its lack of spillway capacity to pass the PMF without overtopping the dam. The spillway is capable of passing a flood equal to 22% of the PMF, and is assessed as "inadequate."

At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam. The following actions, therefore, are recommended along with a timetable for their completion. All recommended actions should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

1. Develop and implement formal operational procedures containing guidelines on sluice operation within twelve months.

2. Establish a flood warning system for the downstream communities within three months.

3. Carry out a more precise hydrologic and hydraulic analysis of the dam within six months, to determine the need and type of mitigating measures necessary. Based on the results of these studies, remedial measures should be instituted. This should include the installation of a tailwater gage.

4. Install observation wells or piezometers in the downstream face of the embankment, and log the borings to determine engineering properties of the dam fill and foundation material. This program and a stability analysis based on the findings should be completed within twelve months.

5. Carry out remedial measures to the dam structure within twelve months, including removal of all debris blocking the downstream road culverts and the channel above the culverts; removal of all trees from the dam crest and downstream slope, from the spillway area and from above the culvert structure; regrading of the downstream slope.

Furthermore, while of a less urgent nature, the following additional action is recommended and should be carried out within a reasonable period of time.

1. Consider providing additional low-level outlet facilities.

2. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam. Annotate and update the existing drawings, and form a coherent as-built set.

3. A formalized program of annual inspection of the dam by an Engineer experienced in the design and construction of dams should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read out during severe rain storms and at routine operating and maintenance vists to the dam. A permanent log should be kept of all maintenance and operating events of the dam and the lake.

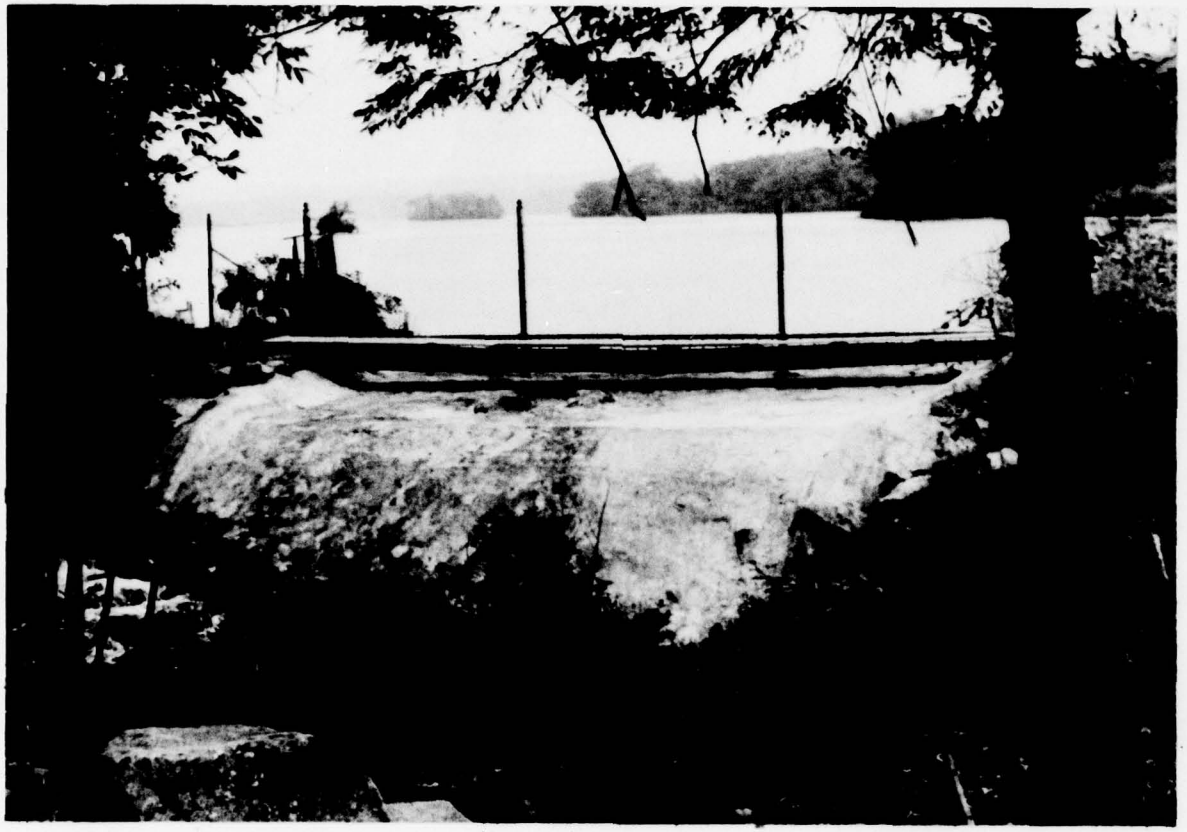
   The downstream embankment face should be checked for seepage at routine visits, and movement or settlement of the dam embankment should be monitored by means of surveying monuments and by measurement of the cracks in the road pavement.

4. Remove the fish trap if no longer needed. Otherwise provide a new one.

A. G. Posch

Anthony G. Posch, P.E.

AGP/REJ/ak



Lake Denmark Dam
View of spillway and lake from downstream.

July 12, 1979

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

LAKE DENMARK DAM, I.D. NJ00001

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

This inspection was made under Contract No. DACW61-79-D-0018 with the Philadelphia District of the Corps of Engineers, in accordance with the terms of Work Order No. 2, at the request of the Facilities Engineer for Picatinny Arsenal.

b. Purpose of Inspection

The visual inspection of Lake Denmark Dam was made on July 12, 1979. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

This report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Lake Denmark Dam is an earth and rock fill embankment about 360 feet long, 12 feet high and with a top width varying from 25 to 140 feet. U.S.G.S. mapping (1914) indicates that this dam is underlain by Pre-Cambrian gneiss bedrock. This is a dense metamorphic rock, containing numerous joint structures. Bedrock also outcrops in the higher knob just east of the spillway, and it is likely that this dam is founded on gneiss bedrock over all or most of its length.

Overhead power cables and a chain-link security fence run along the full length of the dam's crest.

The spillway, located towards the right of the dam, consists of

rock fill with a concrete surface coating. The spillway crest is at 822.65' NGVD and is 30 feet long. A wooden foot-bridge gives pedestrian access across the spillway, and a trash rack is provided at the base of the security fence. Concrete-filled sacks surround the edge of the spillway, and protect the embankment fill.

The dam is provided with three low-level outlets. Two 12" ø cast iron pipes pass through the embankment at the right side of the spillway. Inlet inverts are at elev. 818.05' NGVD. Each pipe is equipped with a gate valve and valve box and is manually operated by means of a standard valve key. In addition, there is a 24" ø outlet located just to the left of the spillway. The inlet invert is at elev. 815.05'. Flow through this outlet is controlled by two 24" square sluice gates which are installed in a concrete valve well near the centerline of the embankment. One sluice gate controls the flow from the reservoir to the valve well and the other controls the flow from the well to the discharge channel. Both sluice gates are manually operated by means of handwheels, installed at the top of the valve well.

Approximately 80 feet downstream of the spillway crest, the discharge channel passes through five 6' diameter concrete culverts under a roadway and railroad embankment. The downstream channel below the culverts is narrow with high, steep sides.

b. Location

Lake Denmark Dam is located within Picatinny Arsenal, a U.S. Military Reservation in the Township of Rockaway, Morris County, New Jersey. It is accessible by means of 25th Avenue which passes immediately downstream of the embankment.

c. Size and Hazard Classification

Lake Denmark Dam has a structural height of 12 feet and a reservoir storage of 3,203 acre-feet. Since its storage capacity lies in the range 1,000 to 50,000 acre-feet, this property governs, and it is classified in the dam size category as being of "intermediate" size. A hazard potential classification of "high" has been assigned to the dam on the basis that failure would result in excessive damage to Building 1200A immediately downstream and to arms/ explosive storage bunkers, roadways and railroads further downstream. Furthermore, failure could cause overtopping and failure of Picatinny Lake Dam 10,000 feet downstream, and subsequent flooding of the main industrial area of the arsenal. It is reasonable to assume that Building 1200A would be evacuated prior to failure of the dam, but the loss of more than a few lives could be expected within the arsenal in the event of overtopping or failure.

d. Ownership

Lake Denmark Dam is owned by the Department of the Army.

Enquiries should be addressed to:

U.S. Army Armanent Research and Development Command
DRDAR-PSE-E
Dover, New Jersey 07801
Attention: C. Berkowitz
(201) 328-2462

e. Purpose of Dam

The dam was constructed primarily to provide water supply for industrial use and fire protection. There is also limited recreational use of the lake.

f. Design and Construction History

Lake Denmark Dam was constructed around 1900 and originally consisted of an earth and rock fill embankment with a dumped rock fill spillway. As of 1946, the dam still had a rock fill spillway, but construction of a road and railroad embankment on the downstream face of the dam embankment had widened and strengthened the structure considerably. At this time, the two 12" ø cast iron outlet pipes were already in place.

In late 1967, the dam was modified by surfacing the rock fill spillway with a layer of concrete. It is believed that the embankment was raised to its present elevation of 825.45' NGVD, and that the 24" ø outlet was installed at this time also.

No major changes have been made since 1967.

g. Normal Operating Procedures

Operation of the dam and reservoir is the responsibility of the Water Systems Tender who is on 24-hour call. There is no formal operating procedure for the dam. Discharge from the lake over the unregulated spillway naturally balances with inflow from Burnt Meadow Brook. When the reservoir level falls below the spillway, the three outlets are opened slightly to maintain a nominal flow in the discharge channel. The lake is not lowered on a regular basis.

In the event of a forecast of heavy rainfall, the operator will open the sluices to draw down the reservoir before the flood.

The operator works by his own judgement, based on many years experience, and operation has thus far proved to be satisfactory.

However, no formal procedures exist to prevent, for instance, flooding of the downstream reaches from excessive discharge over the spillway.

1.3 Pertinent Data

a. Drainage Area	4.5 square miles
b. Discharge At Dam Site	
Maximum known flood at dam site:	965 cfs inflow (estimated peak) of October 1903 flood.
Ungated spillway capacity at elevation of top of dam:	402 cfs (el. 825.45')
Total peak discharge at maximum pool elevation:	7,349 cfs (el. 829.17')
c. Elevation (NGVD)	
Spillway design flood pool:	829.17'
Normal pool:	822.65'
Spillway crest:	822.65'
Lake overflow (top of dam):	825.45'
Streambed at centerline of dam:	813.5'
Maximum tailwater:	825.0' (estimate)
d. Reservoir	
Length of maximum pool:	13,000 feet ± (estimate)
Length of normal pool:	7,000 feet ± (estimate)
e. Storage (Acre-feet)	
Design surcharge:	4,830
Top of dam:	3,203
Spillway crest:	2,257
f. Reservoir Surface (Acres)	
Maximum pool (SDF):	600 estimate
Top of dam:	380 estimate
Spillway crest:	299

g. Dam

Type:	Earth and rock fill embankment.
Length:	360'
Height:	12'
Top width:	25' min. : 140' max.
Side Slopes - Upstream:	1.5H:1V (estimate)
- Downstream:	1.5H:1V (steepest)
Zoning:	Not known
Impervious core:	None
Cutoff:	None
Grout curtain:	None

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	Overflow, unregulated. Rockfill with concrete surface.
Length of weir:	30' (low-point)
Crest elevation:	822.65' NGVD
Gates:	None
U/S Channel:	Lake Denmark
D/S Channel:	Through five 6' ø culverts to Burnt Meadow Brook.

j. Regulating Outlets

Low-level outlets:	1. Two 12" ø C.I. pipes. Right of spillway. 2. One 24" ø pipe. Left of spillway.
Controls:	1. Gate valves. 2. Sluice gates.

SECTION 2: ENGINEERING DATA

2.1 Design

No design computations for the dam are available. One drawing, dated 1967, gives details for resurfacing of the spillway with concrete. No data from soil borings, soil tests or other geotechnical data are available. No cross-sections suitable for assessing stability are available. Data on the hydraulic adequacy of the spillway are contained in the 1962 Passaic River Report and in a 1969 Hydrology and Hydraulics Study of the dams at Picatinny Lake and Lake Denmark.

Correspondence, dated 1946, between Picatinny Arsenal and the New Jersey Department of Conservation, Division of Water Policy and Supply, which deal with the spillway and the possibility of increasing its capacity, are on file.

2.2 Construction

Data is not available concerning the as-built condition of the dam, but construction history available is presented in Section 1.2.f. No data exist of construction methods or borrow sources, nor other data pertinent to the construction of the dam.

2.3 Operation

Formal operation records are not kept for this dam and reservoir. All operation data was obtained verbally from the Water Systems Tender and from the Civil Engineer for the Facilities Engineering Division.

2.4 Evaluation

a. Availability

The availability of engineering data is poor. All engineering data quoted were available from the Facilities Engineering Division.

b. Adequacy

The engineering data available, together with that obtained in the field, were adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform even approximate computations of the dam's stability, but an evaluation could be made based on visual observation.

The 1969 Hydrology and Hydraulics Study examines the effect downstream of a flood with an expected 50-year return period. For a Phase I study this is not adequate, but the report contains

some useful information on the ground floor elevation of important downstream buildings.

The 1962 Passaic River Report gives the predicted flow rate for a PMF, but information on the method used to obtain the flow rate is not available.

c. Validity

The plan of the proposed concrete surfacing of the spillway does not correspond with the as-built condition. The spillway has been rebuilt since the 1962 and 1969 studies were made, which invalidates the rating curves used in the studies. It should be noted that the rebuilt spillway does not conform to the one suggested in the 1962 Passaic River Report. The Storage capacity of the lake, given in the studies, appears to correspond approximately with that computed, up to an elevation of 818' NGVD. Data on dam length and height do not correspond to those found during the visual inspection.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection of Lake Denmark Dam revealed that the dam and spillway were in serviceable condition, but that some remedial action followed by a regular program of inspection and repair is required to maintain its serviceability. The reservoir stage was lowered below the spillway crest for the inspection.

b. Dam

The embankment of the dam is covered with rip-rap on upstream and downstream faces. It is unknown whether this rip-rap is also part of the interior of the earth fill structure. The steep embankment slopes south of the roadway are covered with mature tree growth. No seeps or springs were noted on either east or west embankments. The slopes adjacent to the outlet stream and spillway also appeared dry. Horizontal and vertical alignment appeared to be good.

Minor, localized sliding of individual rip-rap blocks on the steep, south embankment were noted. Cracks were noted in the asphalt roadway crossing the dam. These cracks run parallel to the dam axis. They may be indicative of differential settlement or expansion and cracking of the underlying embankment material.

The headwater gage was in good condition.

c. Appurtenant Structures

1. Spillway

The spillway was basically in good condition. The concrete surfacing and concrete-filled bags exhibited no sign of deterioration. The timber footbridge across the spillway was satisfactory and the trash rack was clear. Water was not flowing over the spillway at the time of inspection.

2. Downstream Road-culverts

The set of five 6' diameter culverts which pass the spillway discharge under the roadway appeared in satisfactory condition. The westernmost culvert was partially blocked at the south end by rock rubble. Alignment of the culverts was good. The masonry support structure for the culverts has been recently repointed, but some trees are growing above the culverts.

3. Low-level Outlets

All low-level outlets were operated, and seen to be in good working condition. On the day of inspection, the reservoir was 1 to 2 feet below the spillway crest. All three low-level outlets were partially open; presumably in order to maintain a flow in the channel. The fish-trap through which the 12-inch diameter pipes discharge was totally deteriorated.

d. Reservoir Area

Sedimentation is reported to be negligible. The slopes surrounding the reservoir are steep and heavily wooded, and an access road runs along the right bank. At the reservoir rim, the slopes flatten out and are grass-covered. No evidence was found to indicate slope instability. At the upstream, north-eastern end, the reservoir is very shallow to swampy. Some high-security storage buildings are located on the right bank, and a small-boat stage has been built on the left end of the dam.

e. Downstream Channel

Dark gneissic bedrock outcrops in the outlet stream channel adjacent to and downstream from the spillway. Joints in bedrock of this type can provide channels for leakage of water under or around a dam if not identified and properly sealed during construction. The downstream channel below the culvert structure is well defined and flows through a steep-sided gorge. No evidence of seepage was found in the banks. A heavy growth of trees and vegetation has developed on the channel banks, but flow is not significantly impeded. Burnt Meadow Brook joins Green Pond Brook approximately 1,200 feet downstream of the spillway. The stream flows over a 2-foot high weir 1,300 feet downstream and passes through an area of storage bunkers before entering Picatinny Lake. The stream is crossed by road and rail bridges which have great importance for access within the arsenal.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

Operation of the dam and reservoir is the responsibility of the Water Systems Tender who is on 24-hour call. Discharge from the lake over the unregulated spillway naturally balances with inflow from Burnt Meadow Brook. When the reservoir level falls below the spillway, the three outlets are opened slightly to maintain a nominal flow in the discharge channel. The lake is not lowered on a regular basis. In the event of a forecast of heavy rainfall, the operator will open the sluices to draw down the reservoir before the flood.

The operator works by his own judgement, based on many years experience, and operation has thus far proved to be satisfactory. However, no formal procedures exist to prevent, for instance, flooding of the downstream reaches from excessive discharge over the spillway.

4.2 Maintenance of the Dam

The dam is maintained on an irregular schedule, as and when the need for repairs becomes pressing. There is no regular program of inspection and maintenance. Maintenance of the dam is under the jurisdiction of the Facilities Engineering Division of Picatinny Arsenal.

4.3 Maintenance of Operating Facilities

The operating facilities consist of the four low-level outlet sluice gates, and these are under the day-to-day supervision of the Water Systems Tender. Sufficient maintenance has been carried out to insure that all the facilities remain in good working order.

4.4 Evaluation

The operational procedures for Lake Denmark Dam have so far proved satisfactory, but the lack of formally approved procedures relating reservoir stage, rainfall etc. to the number of sluices to be opened is not considered conducive to satisfactory future operation.

The maintenance procedures for the operating facilities are considered to be adequate, but the dam and spillway exhibit a lack of adequate maintenance.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Lake Denmark Dam is approximately 4.5 square miles. A drainage map of the watershed of the dam site is presented in Appendix D.

The topography within the basin is steeply to moderately sloped. Elevations range from approximately 1,200 feet above NGVD at the north-east end of the watershed to about 820 feet at the dam. Land use patterns within the watershed are mostly forest, with light industrial development. The hydraulic and hydrologic studies of 1962 and 1969 were not used as a basis for this study. The evaluation of the hydraulic and hydrologic features of the lake was based on criteria set forth in the Corps Guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The SDF for the dam is the PMF.

The probable maximum flood (PMF) was calculated from the probable maximum precipitation using Hydrometeorological Report No. 33 with standard reduction factors. Due to the small drainage area, the SCS triangular hydrograph transformed to a curvilinear hydrograph was adopted for developing the unit hydrograph for Lake Denmark with the aid of the HEC-1DB Flood Hydrograph Computer program.

Initial and infiltration loss rates, were applied to the Probable Maximum Precipitation to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrograph to obtain the PMF and various ratios of PMF utilizing program HEC-1DB.

The SDF peak outflow calculated for Lake Denmark Dam is 7,349 cfs. This value is derived from the PMF, and results in overtopping of the dam.

The stage-outflow relation for the spillway was prepared from field notes and sketches. The reservoir stage capacity was based on the U.S.G.S. Quadrangle Topographic Maps. The reservoir stage storage relationship was computed directly by the conic method, utilizing the HEC-1DB program. The conic method assumes that the reservoir capacity resembles a series of vertically stacked cones. The reservoir surface areas at various elevations were measured by planimeters from topographic maps. Reservoir storage capacity included surcharge levels exceeding the top of the dam, and the spillway rating curve was based on the assumption that the dam remains intact during routing. The spillway rating curve is pre-

sented in the hydrologic computations.

A breach analysis indicated that the hazard potential for loss of life downstream, due to dam failure from overtopping is not significantly greater than that which exists without failure. At a flow of 30% of the PMF, there will be a rise of 4.2 feet in water surface elevation at the downstream reach due to dam failure. This increases the potential for damage to property, but not significantly for loss of life, since the endangered buildings are unoccupied storage bunkers. It is reasonable to assume that Building 1200A, immediately downstream of the dam, would be evacuated prior to failure. A drawdown computation was made to determine the time required to lower the reservoir from the spillway crest elevation to an elevation of 815.8' NGVD, the assumed lowest elevation for drawdown. With all outlets open and a constant inflow of 2 cfs/square mile, the time to lower the reservoir is 55 days. This is grossly inadequate for emergency draining of the reservoir and additional emergency facilities should be considered.

b. Experience Data

The greatest known flood to have occurred at this site was in October, 1903, before the existing dam was constructed. No records of reservoir stage or spillway discharge are maintained but it is known that the dam has not been overtopped in its present form.

c. Visual Observation

Industrial development immediately below the dam is light. Building 1200A is located approximately 200 feet below the left embankment, and running across the dam are overhead electric cables, a road and a railroad. In the floodpath are storage bunkers and important access bridges, and below Picatinny Lake is the main industrial center of the arsenal.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 3.7 feet. Computations indicate that the dam can pass approximately 22% of the PMF without overtopping the dam crest. Since the PMF is the Spillway Design Flood (SDF) for this dam, and since the hazard potential for loss of life downstream due to dam failure caused by overtopping is not significantly greater than that which exists without failure, the spillway capacity for Lake Denmark Dam is assessed as "inadequate."

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There are no major signs of distress in the embankments or spillway of Lake Denmark Dam. Horizontal and vertical alignments are good. The parallel cracks found in the road pavement may be indicative of settlement of the downstream face and should be monitored, but it is possible that the cracks are due to frost action on the road. Large trees in the spillway area and on the steep downstream embankment face could pose a threat to stability. The downstream slope appears rather steep and should be regraded.

b. Design and Construction Data

No design computations relating to stability were uncovered during the report preparation phase. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction are available for use in the stability analysis. The cross-sections shown on the drawing need to be validated to be meaningful for a stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam. The dam and spillway have served satisfactorily since the widening and rehabilitation in the early 1940's.

d. Post-Construction Changes

A history of the dam is given in Section 1.2.f. The principal changes relating to the stability of the dam are: the widening of the dam by building the road and rail embankment downstream, the provision of concrete surfacing on the rockfill spillway in 1967.

e. Static Stability

A static stability analysis was not performed for Lake Denmark Dam because the lack of data on which to base assumptions of material properties and embankment cross-sections might produce misleading results. The recommended remedial actions must be implemented in order to decrease the risk of local failure, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory.

However, this can only be confirmed by detailed analysis, based on additional information on constituent rockfill and soil parameters, foundation conditions and embankment cross-sections.

f. Seismic Stability

Two faults are mapped several hundred feet west of the dam, along the base of Green Pond Mountain. These are very ancient faults and are considered to be completely inactive.

The dam is located in Seismic Zone 1, as defined in Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist. Since static stability safety factors are considered to be adequate, seismic stability may be assumed to be satisfactory.

SECTION 7: ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase I report.

The adequacy of Lake Denmark Dam is in question because the dam does not have adequate spillway capacity to pass the PMF without overtopping. The dam is considered to be able to withstand some overtopping without being breached, but the predicted overtopping of 3.7 feet in the event of a PMF carries with it the danger of progressive failure. The dam's present spillway capacity is only about 22% of the PMF.

No definitive statement pertaining to the safety of the embankment can be made without acquisition of embankment and foundation material engineering properties and determination of phreatic levels in the downstream part of the embankment. The present embankment, however, has performed adequately since its construction, without failure or major evidence of instability.

b. Adequacy of Information

The information uncovered was adequate to perform hydraulic and hydrologic computations. The data was insufficient to perform even an approximate computation of the dam's stability. An assessment of the dam could be made by visual observation only.

c. Urgency of Studies

All recommended studies should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

A more precise hydrologic and hydraulic analysis of the dam should be conducted within six months, to determine the need and type of mitigating measures necessary. This should include the installation of a tailwater gage, and determination of the ability of the dam to withstand overtopping.

Observation wells or piezometers should be installed in the bore holes in the downstream slope of the embankment to obtain soil samples and to determine the location of the phreatic surface. The borings should be logged according to the Unified Soil Class-

ification system by qualified personnel and samples taken to determine the values of pertinent fill parameters. Stability analyses should then be performed in accordance with Chapter 4.4 of the Corps Guidelines. This work should be commenced within 12 months.

A complete topographic survey of the dam area should be made within 12 months, in order to develop a detailed plan and several cross-sections of the dam. The location of utilities on the dam should be shown in the drawings, and any benchmarks shown. The headwater gage datum should be checked during the survey.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Increase the dam height, thus permitting a higher discharge to pass over the spillway and reducing the possibility of overtopping.

2. Lower the weir crest elevation.

3. Widen the weir structure.

4. A combination of any of the above alternatives.

b. Other Remedial Measures, to be undertaken within 12 months.

1. Remove all debris blocking the downstream road culverts and the channel above the culverts.

2. Remove all trees from the dam crest and downstream slope, from the spillway area and from above the culvert structure. Regrade the downstream slope.

c. Recommendations

The following additional action is recommended.

1. Consider providing additional low-level outlet facilities.

2. Establish a flood warning system for the downstream communities within three months.

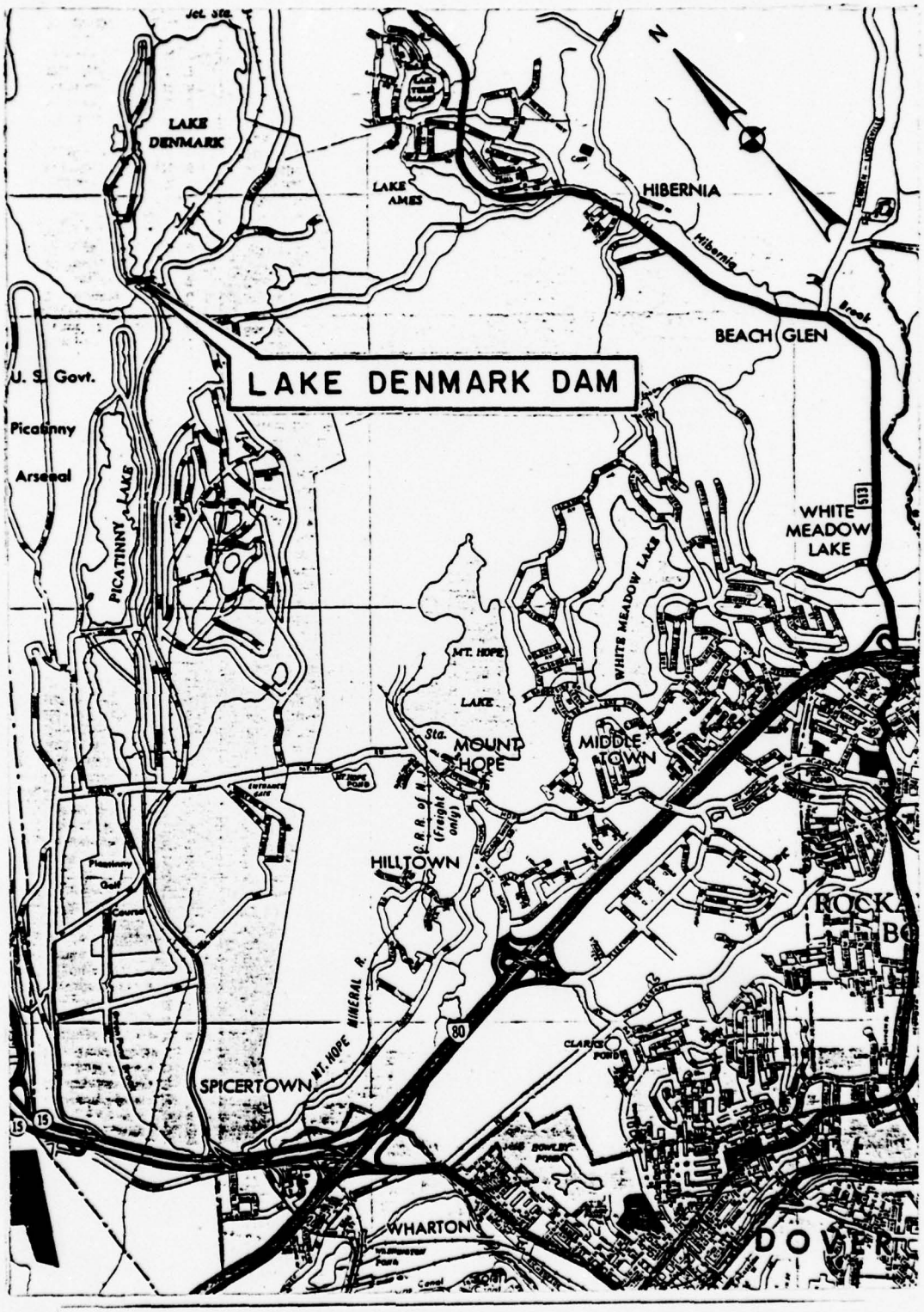
3. Review the present operational procedures, and develop specific guidelines on valve operation and emergency procedures. The guidelines, to be agreed upon by upstream and downstream users and by all parties concerned, should be implemented within 12 months.

4. Remove the fish trap if no longer needed. Otherwise provide a new trap.

d. O & M Procedures

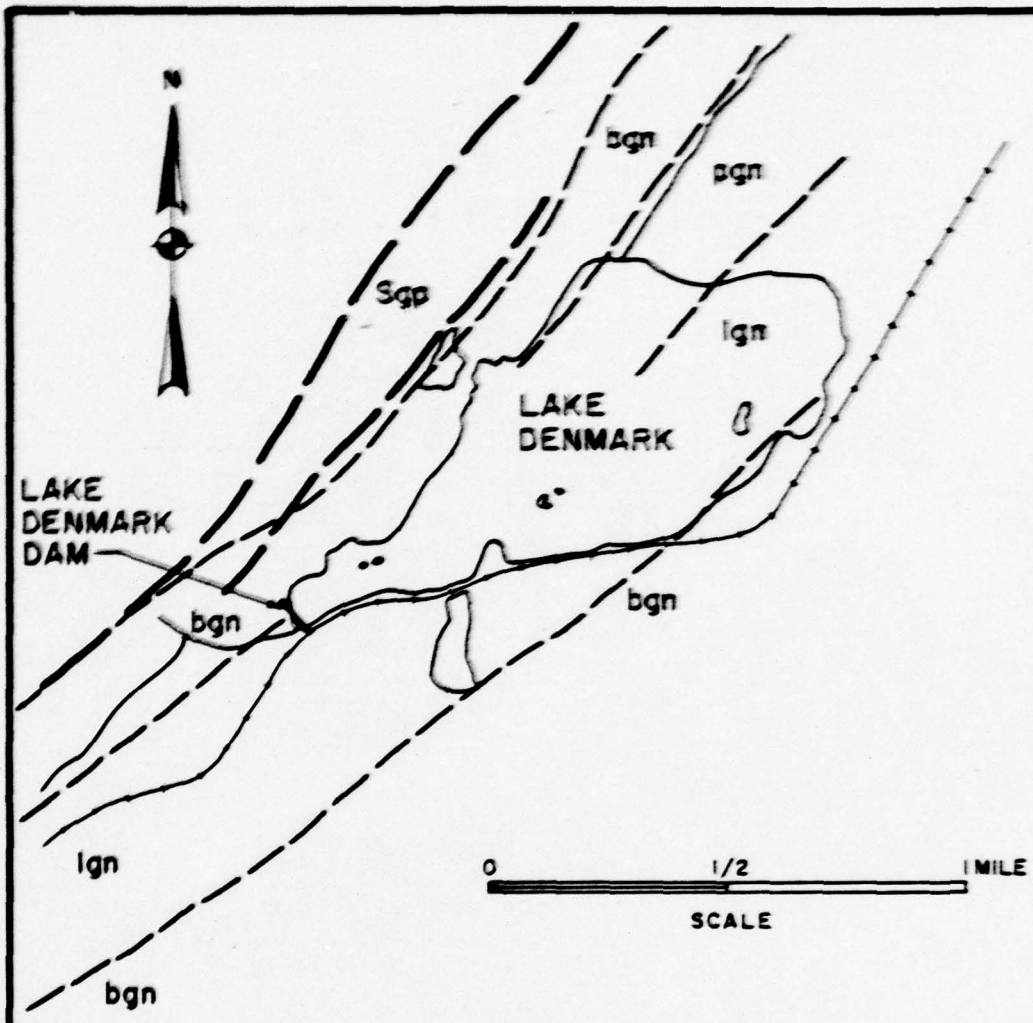
A formalized program of annual inspection of the dam by an experienced party should be initiated, utilizing the standard visual check list in this report. Headwater and tailwater gages should be read out during severe rain storms and at routine operating and maintenance visits to the dam. A permanent log should be kept of all maintenance and operating events of the dam and the lake. The downstream embankment face should be checked for seepage at routine visits, and movement or settlement of the dam embankment should be monitored by means of surveying monuments and by measurement of the cracks in the road pavement.

PLATES



VICINITY MAP

PLATE 1

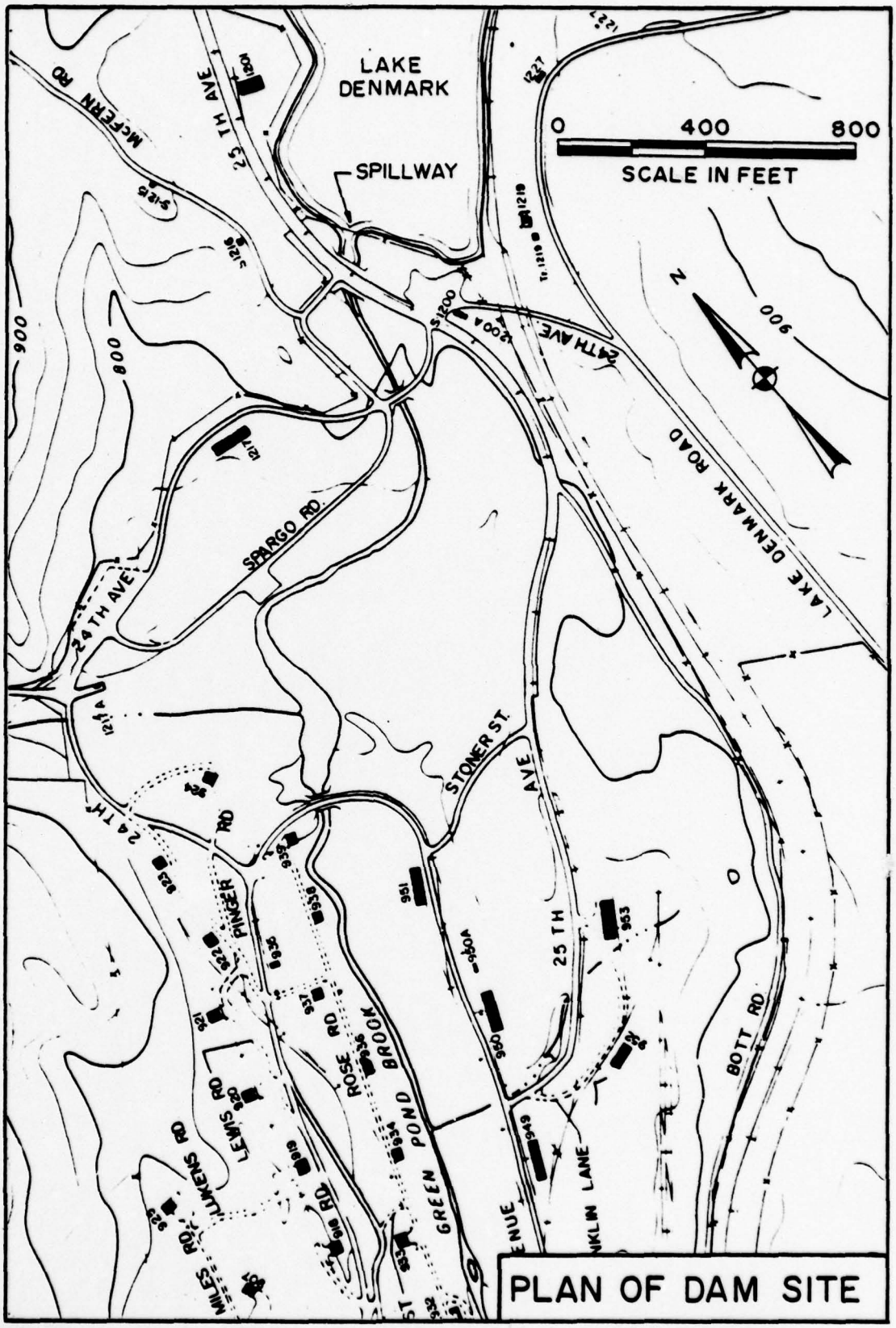


LEGEND

———	FAULT (HIGH ANGLE)
———	APPROX. CONTACT BETWEEN BEDROCK UNITS
Sgp	GREENPOND CONGLOMERATE
€ok	KITTATINNY DOLOSTONE
€h	HARDYSTONE QUARTZITE
bgn	BYRAM GNEISS
lgn	LOSEE GNEISS
pgn	POCHUNK GNEISS

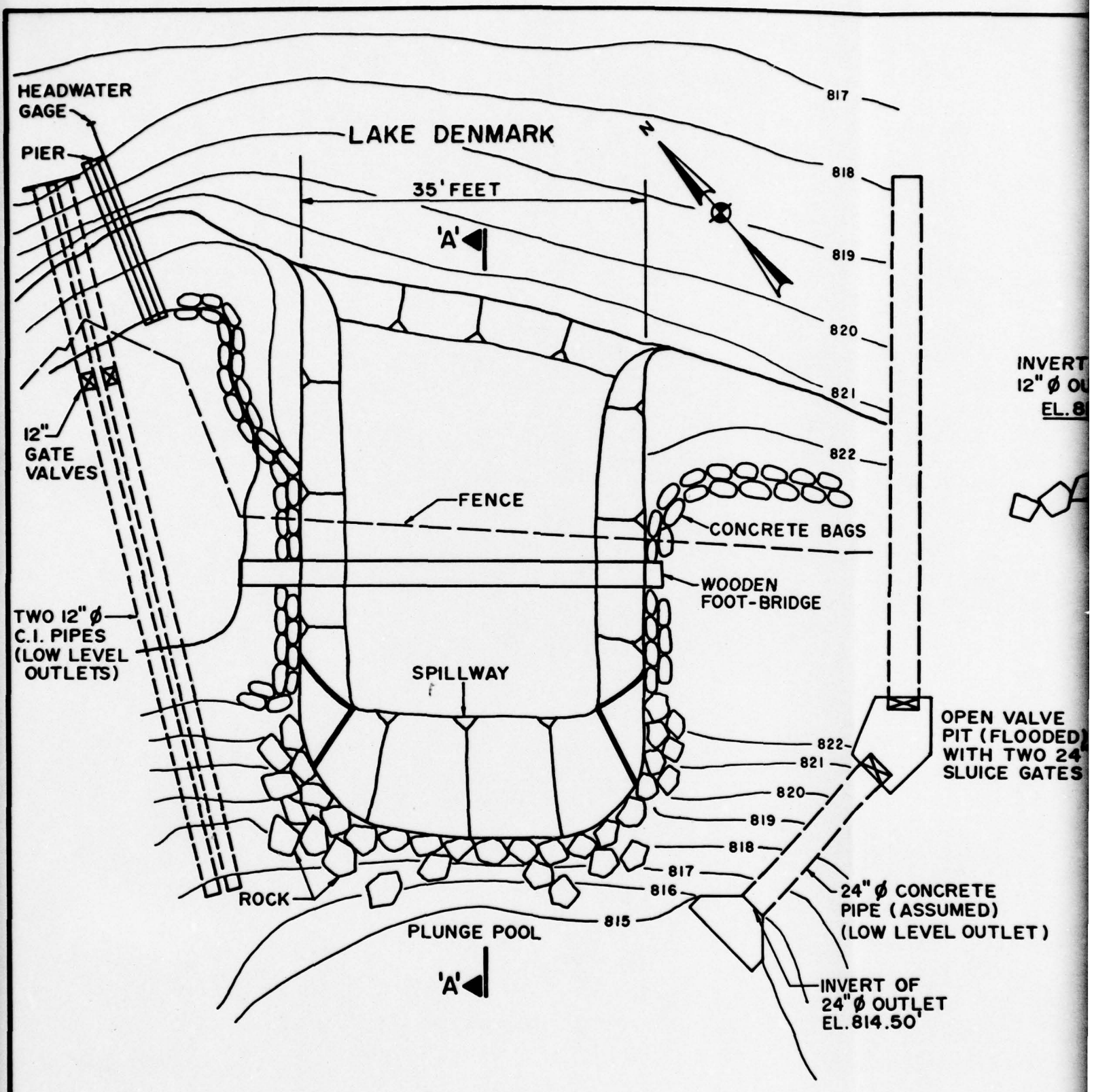
GEOLOGIC MAP
LAKE DENMARK DAM

PLATE 2



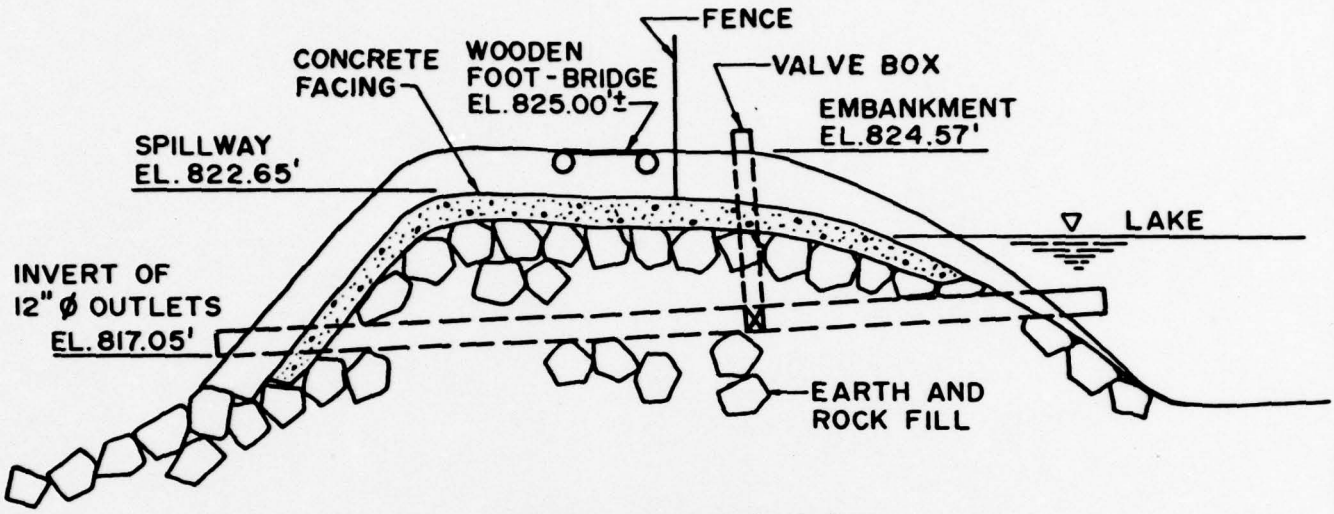
NOTE: PLAN IS REPRODUCED FROM F.E.D. (DOVER) GENERAL SITE MAP, SHEET 2, WITH ADDENDA.

PLATE 3



PLAN OF SPILLWAY

1



SECTION 'A'-'A'

OPEN VALVE PIT (FLOODED) WITH TWO 24" SLUICE GATES

24" Ø CONCRETE PIPE (ASSUMED) (LOW LEVEL OUTLET)

VERT OF Ø OUTLET .814.50'

2

NOTE:
ELEVATIONS SHOWN ARE TO NGVD.

LAKE DENMARK
SPILLWAY DETAILS
SKETCH PREPARED FROM FIELD NOTES, NOT TO SCALE
JULY 12, 1979

PLATE 4

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION, MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION

PHASE I

Name of Dam Lake Denmark County Morris State New Jersey Coordinators COE

Date(s) Inspection July 12, 1979 Weather Sunny Temperature 80°F

Pool elevation at Time of Inspection 820.9' M.S.L. Tailwater at time of Inspection 813.8' M.S.L.

Inspection Personnel:

C. Chinn
R. Ernest-Jones
R. Fickies
W. Flynn
H. King

Owner/Representative:

C. Berkowitz, Civil Engineer (F.E.D. Picatinny Arsenal)

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS	Cracks approximately 1/8" wide in road pavement over embankment. Cracks are parallel to dam axis. Could be due to settlement of roadway embankment material; or due to freezing and thawing of the roadway subgrade. No other cracks noted.	Cracks should be monitored to determine if they increase in width with time.
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None, other than minor slipping of individual stones on downstream slope of embankment.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Downstream face of road embankment is sloped at steeper than 1.5H:1V. Slope is mainly rock. No erosion noted. Heavy tree growth covering rocks.	Remove trees from the downstream slope. The slope should be re-graded.
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST	No vertical misalignment noted, other than evidenced by parallel cracks in road. Visibility of horizontal alignment is obscured by tree growth, and by the poorly defined shape of the dam.	No significant misalignment.
RIPRAP FAILURES	Occasional individual stones have slipped.	No action.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
TREES & VEGETATION	A dense growth of trees and brush is covering a large amount of the dam.	Remove trees growing on the crest, over the road culverts, and on the downstream slope.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Junctions appear sound. No leakage noted. Crest is protected by concrete bags on both sides of the spillway.	
ANY NOTICEABLE SEEPAGE	None. The downstream slope below the road was examined, as were downstream channel banks to 200 feet below the culvert.	Check for signs of seepage at each O & M inspection.
STAFF GAGE AND RECORDER	Headwater gage only, located at the end of a short pier, showing water level in lake to MSL in 0.1' graduations. Gage is in good condition.	Check gage datum when performing topographic survey of dam. Install a tailwater gage.
DRAINS	None.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONCRETE WEIR	Concrete facing to original rockfill spillway, placed within the last 8 years, is in good condition. Chain-link fence delineating restricted zone is located along crest of whole dam and spillway. The 3' wide timber footbridge across the spillway is in good condition.	Footbridge is expected to wash out in the event of overtopping, and should be disregarded for hydraulic computations.
APPROACH CHANNEL	At base of fence, a trash screen across the approach channel keeps debris from crossing the spillway. The screen was clear at the inspection.	
DISCHARGE CHANNEL	Trees on the banks of the discharge channel have been recently cut down between the spillway and the road/rail embankment. Channel is rock-strewn and not well defined.	Remove all trees from this area.
BRIDGE AND PIERS	Located 80 feet downstream of the spillway, is a rail and road culvert structure of masonary with five 6' ø concrete culverts passing through. The culverts are about 75' long. The masonary structure is in good condition, and has been recently re-pointed. Some trees are growing above the structure. Alignment of the culverts is good, but some are partly blocked.	Remove trees from above culvert structure. Remove debris from all culverts.

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN	The structure is not provided with a stilling basin. The discharge channel is rocky and effectively dissipates the energy of the flow.	
INTAKE STRUCTURE	Upstream ends of the two 12" ø low-level outlet pipes terminate in a small concrete headwall located on the upstream slope of the embankment. The intakes were visible below the surface of the lake and were in good condition. The intake for the 24" ø low-level outlet was not visible.	
OUTLET STRUCTURE	The two 12" ø outlets terminate at the right side of the discharge channel immediately adjacent to the spillway. The 24" ø outlet terminates at the left side of the channel. The discharge areas on both sides are rock-covered and erosion is not a problem. The 12" ø outlets discharge through a deteriorated fish-trap.	Repair fish-trap if required.
OUTLET FACILITIES	The two 12" ø outlets are each equipped with a gate valve located near the middle of the line about 5 feet below the top of the embankment. The valves are manually operated with a key stored nearby. The 24" ø outlet is controlled by two manually operated 24" square sluice gates, located in a small concrete box extending down into the embankment. One gate controls the flow from the reservoir into the box, and the other controls the flow from the box to the discharge channel. All outlets are operable and in good condition.	No action.
EMERGENCY GATE	None.	

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/SURVEYS	A benchmark is reported to be near the dam, but was not found at the inspection.	Chart the benchmark on an annotated drawing, following the topographic survey.
OBSERVATION WELLS	None.	
WEIRS	A small (2-foot high) weir exists about 1,300' downstream of the dam. The stream elevation measurement device is missing.	
PIEZOMETERS	None.	
OTHERS	See "STAFF GAGE & RECORDER".	

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SLOPES	Medium to steep. Heavy cover of trees. Flatten out, becoming grass-covered at the rim. No evidence of slope instability. Upstream half of reservoir is very flat and swampy.	
SEDIMENTATION	Negligible. Swampy at upstream end.	Investigate storage capacity in more detail.
USE	Cooling water supply to industrial buildings and feed to fire-main. Minor recreational use.	
SHORELINE BUILDINGS	One or two boat stages. High security arsenal buildings.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	The downstream channel has a rock bottom. Immediately below the spillway it is poorly defined and flow is obstructed by fallen trees. Eighty feet below the spillway are five 6' ø concrete culverts, two of which are partly blocked. Below the culverts, stream winds through well-defined deep valley.	Remove all debris from culverts and from channel above culverts.
SLOPES	Steeper than 1.5H:1V below the road culverts. Slopes are covered with trees.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	Just below the left embankment is Building 1200A which is regularly occupied. Below the confluence of Burnt Meadow Brook with Green Pond Brook, is an area containing many arms/explosive storage bunkers, below which is Picatinny Lake. Downstream of Picatinny Lake is the main industrial area of the arsenal, ~~several army residences, State Route 15, Interstate 80, and the city of Dover~~ (5 miles downstream).	Bldg. 1200A would be washed out by a breach of the left embankment. The presence of the industrial center downstream ~~confirms "high" hazard.~~

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None available.
REGIONAL VICINITY MAP	Available - County map for Morris County - U.S.G.S. Quadrangle Sheets for Dover, Boonton, Franklin and Newfoundland, New Jersey - Picatinny Arsenal general site map (F.E.D., Picatinny)
CONSTRUCTION HISTORY	Spillway resurfaced circa. 1967. No other information available.
TYPICAL SECTIONS OF DAM	None available.
HYDROLOGIC/HYDRAULIC DATA	Some data available on 1962 Passaic River Report (unpublished). Picatinny Arsenal Engineering Report No 16:69, April 14, 1969, (F.E.D., Picatinny)
OUTLETS - PLAN	None - sketch from field notes included herein (Plate 4).
- DETAILS	None
- CONSTRAINTS	None
- DISCHARGE RATINGS	None
RAINFALL/RESERVOIR RECORDS	None

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	None available.
DESIGN COMPUTATIONS	None available.
HYDROLOGY & HYDRAULICS	Post Construction H & H Studies - Listed on following page.
DAM STABILITY	None available.
SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS	None available.
BORING RECORDS	None available.
LABORATORY	None available.
FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Unknown.
SPILLWAY PLAN - SECTIONS	Plan available showing extent of concrete work needed to surface spillway (Drg. DP-143963, F.E.D. Picatinny).
- DETAILS	No sections or details available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	None available - sketch from field notes included herein.
MONITORING SYSTEMS	Not applicable (none installed).
MODIFICATIONS	None.
HIGH POOL RECORDS	None.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available on the dam structure. Hydrologic/Hydaulic Studies: - Passaic River Report (1962-unpublished) - Picatinny Arsenal Engineering Report No. 16:69, April 14, 1969.
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	None
MAINTENANCE OPERATION RECORDS	None kept.

APPENDIX B

PHOTOGRAPHS

(Taken on July 12, 1979)

Photo No. 1 - Overall view of upstream face of dam. Note the heavy tree-growth on the dam, the spillway to the right of center and the boating facilities to the left. Note also the power cables across the dam and the building downstream.

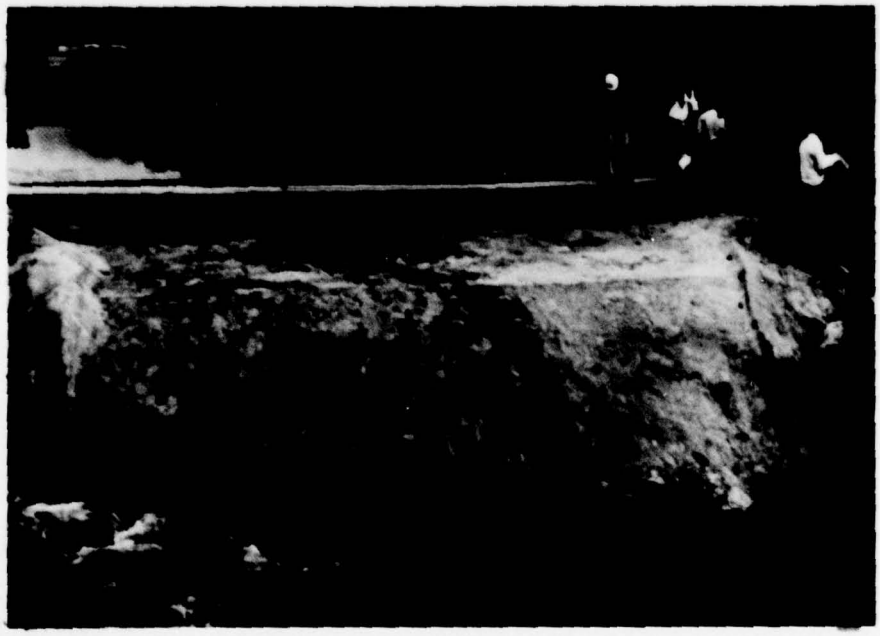


Photo No. 2 - View of left side of spillway. Note the deterioration of the concrete rendering at the downstream toe, and the rockfill protruding through the level surface. The trash screen can just be seen behind the footbridge, at the base of the security fence.

Photo No. 3 - View of right side of spillway. Discharge from the lake was through the two 12" diameter low-level outlets. What is assumed to have been a fish trap at the discharge end, is now totally deteriorated.

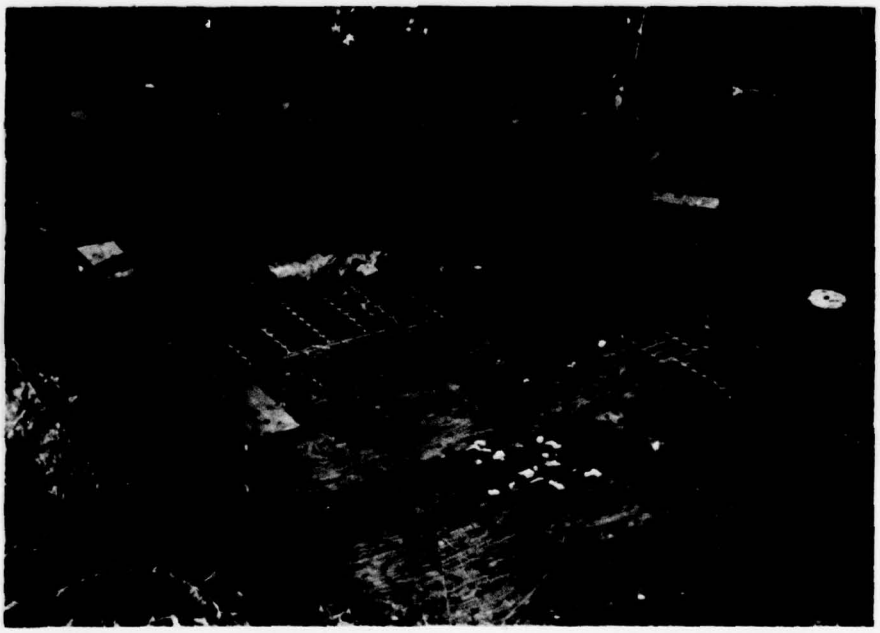


Photo No. 4 - Detail of the gate-valve operators in the open valve pit to the left of the spillway, controlling a single 24" diameter low-level outlet. All valves were demonstrated to be operable.

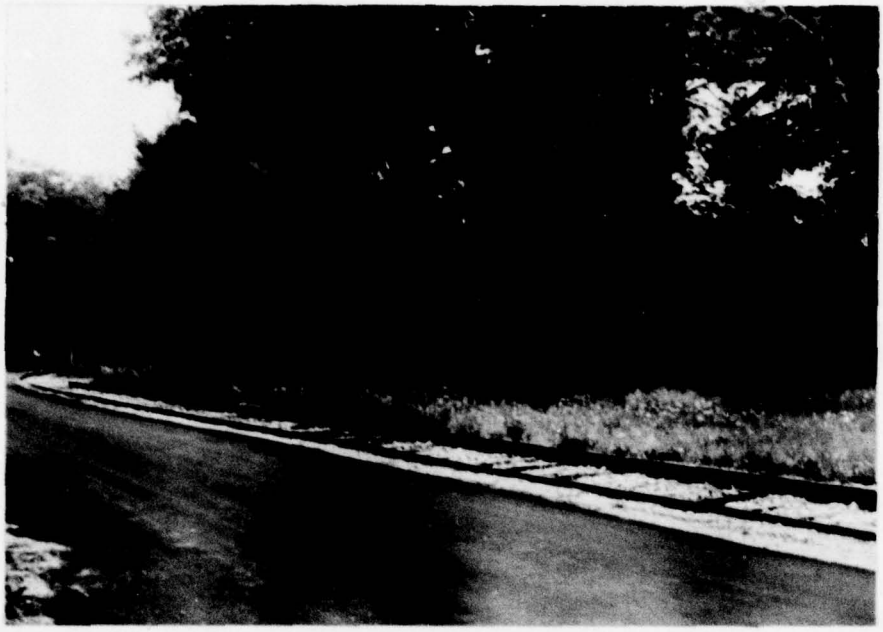


Photo No. 5 - View of rock outcrop in the center of the downstream face of the dam. The road and railroad downstream of the dam are essential access routes within the arsenal.

Photo No. 6 - View of the left side of the dam embankment taken from the outcrop.

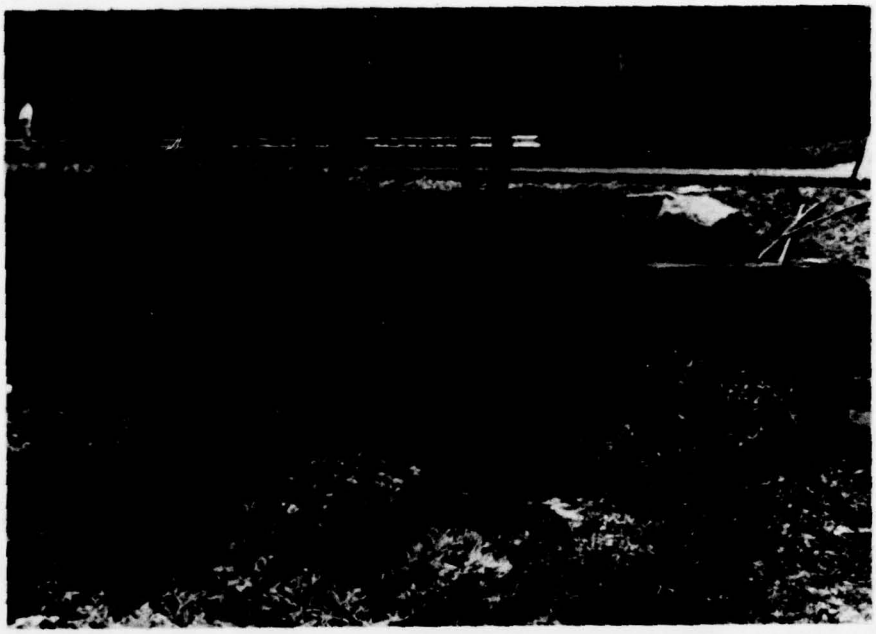


Photo No. 7 - View of the upstream end of the 72" diameter concrete road culverts which carry the discharge from below the spillway, under the road and railroad. Note the generally good level of maintenance.

Photo No. 8 - Downstream end of the concrete culverts. Settlement cracks and recent repointing are evident.

Photo No. 9 - View of downstream channel, below road culverts. Note that the channel is cut in the bedrock and that the valley sides are steep and tree-covered.

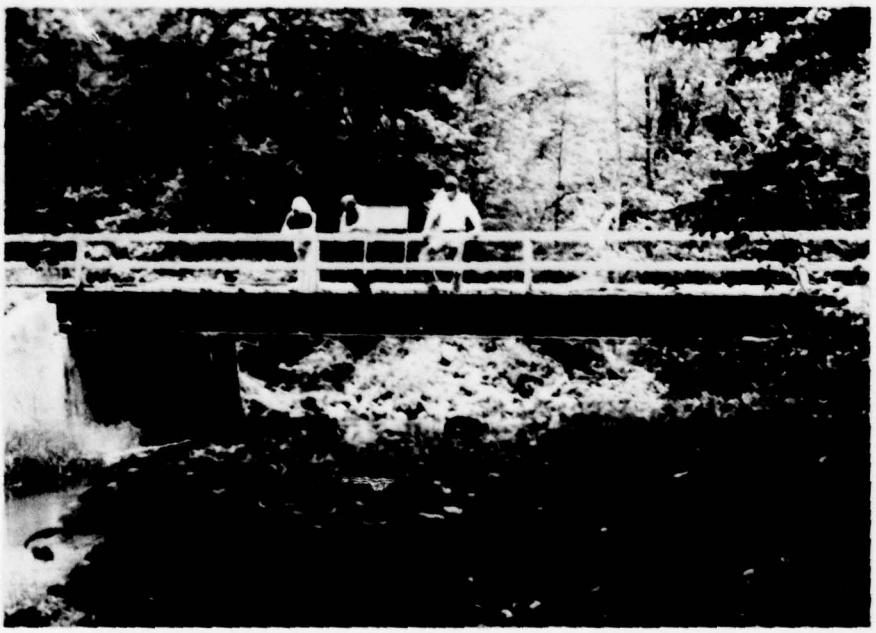


Photo No. 10 - View of railroad bridge 1,700 feet downstream of dam.

APPENDIX C

SUMMARY OF ENGINEERING DATA

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: Lake Denmark Dam

Drainage Area Characteristics: Wooded, mountain area mostly undeveloped.

Elevation Top Normal Pool (Storage Capacity): 822.65' NGVD (2,257 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: (SDF) 829.2' NGVD (4,830 acre-feet)

Elevation Top Dam: 825.45' NGVD (3,023 acre-feet)

SPILLWAY CREST

a. Elevation 822.65' NGVD

b. Type Unregulated broad-crested weir - concrete

c. Width 25'

d. Length 30'

e. Location Spillover Right end of embankment.

f. No. and Type of Gates None.

OUTLET WORK

a. Type Three pipes through embankment one - 24" ø with sluice gate
two - 12" ø with gate valves.

b. Location Two 12" ø-left of spillway, 24" ø-right of spillway.

c. Entrance Inverts Two 12" ø-elev. 818.05' (assumed), 24" ø-elev. 815.50' (assumed)

d. Exit Inverts Two 12" ø-elev. 817.05', 24" ø-elev. 814.50'

e. Emergency Draindown Facilities None.

HYDROMETEOROLOGICAL GAGES

a. Type None

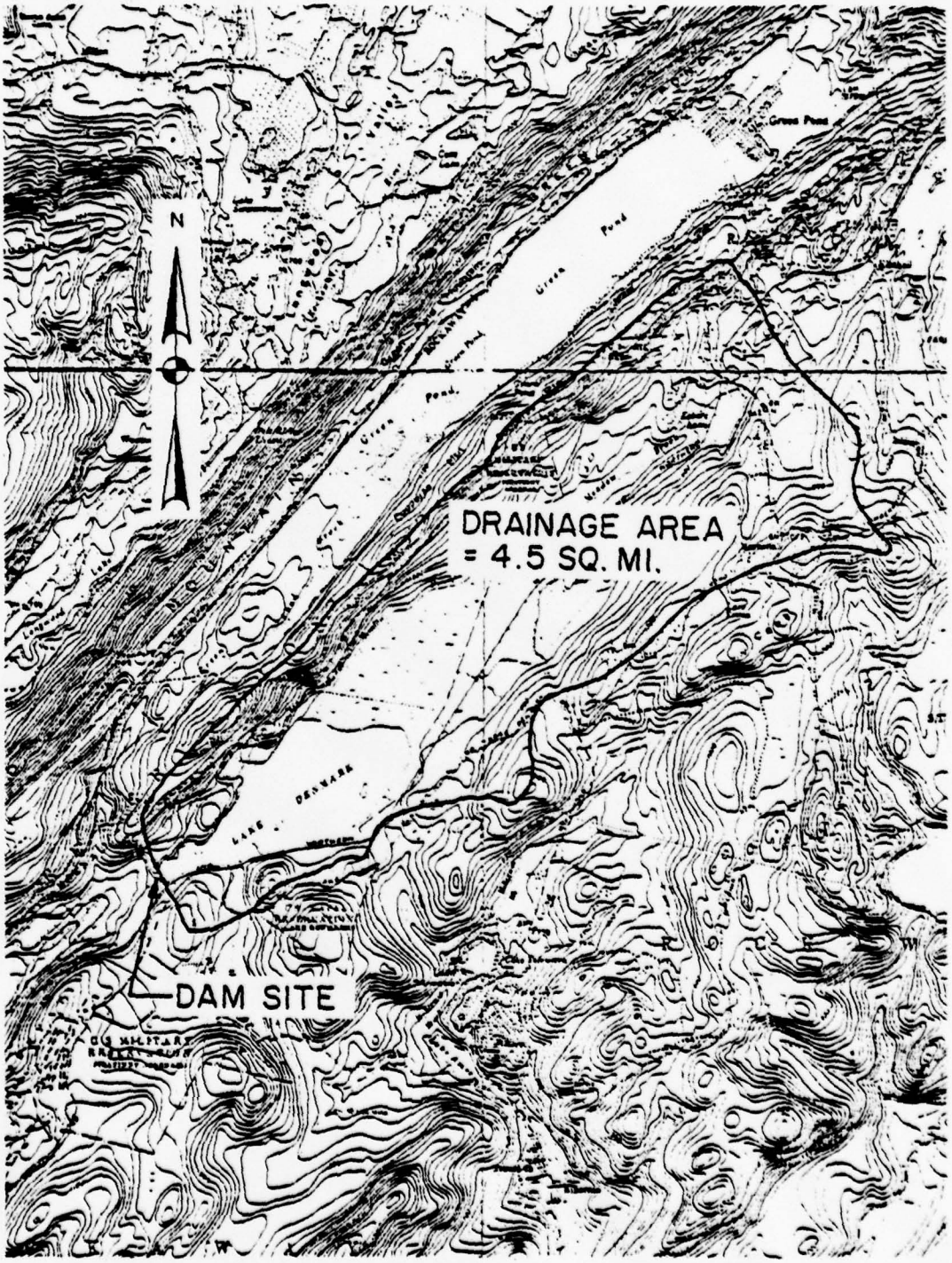
b. Location None

c. Records None

MAXIMUM NON-DAMAGING DISCHARGE 402 cfs

APPENDIX D

HYDROLOGIC COMPUTATIONS



LAKE DENMARK DAM
DRAINAGE BASIN

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection SHEET NO. 1 OF
Lake Denmark Dam JOB NO. 10-A44-02
COMPUTED BY S.B. CHECKED BY DATE Aug, 1979

. Surface Area of Impoundment = 299 Ac
Volume " " = 3203 Ac-ft.
Max height of dam " = 12 Ft

Classification of Dam = Intermediate

SDF for Intermediate Size, High Hazard
= PMF

Hydrologic Analysis

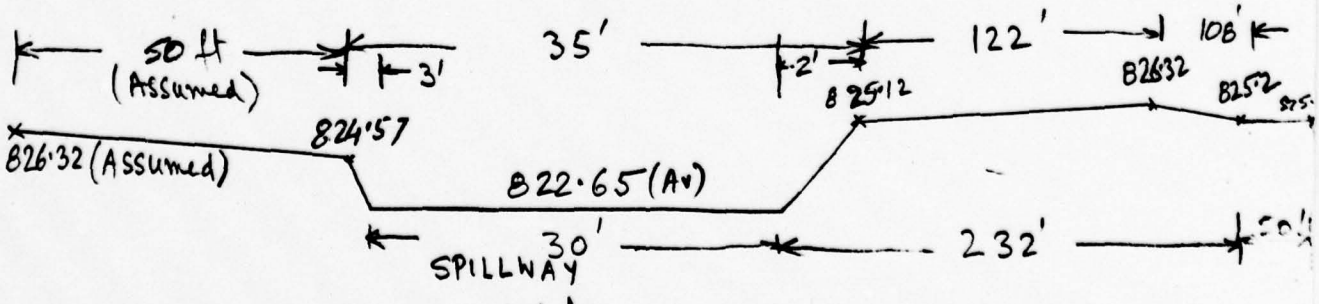
D.A = 4.5 Sq. miles

Inflow Hydrograph at Dam was determined using HEC 1 DB program.

The inflow routed through reservoir to get outflow.

Spillway and Dam

El 20 = 825 of U.S.G.S
Add 805 with the Survey D



Low level outlets 1. Invert: 818·05 (2 nos 12" pipe)
2. " " : 815·50 (1-24" line)

Outlets are assumed closed at high flow.
Outlet invert 1' below inlet invert.

Both the spillway and Dam are considered as broad crested weir. The low level outlets are considered closed in high flow. Gates (valves) can be opened in low flow conditions.

①
Length of Spillway = 30'
Spillway Invert = 822.65 Av
C = 2.65

$$Q_1 = 2.65 \times 30 (H - 822.65)^{1.5} = 79.5 (H - 822.65)^{1.5}$$

② Left Dam and extreme right: Length = 100 ft (estimated); Invert = 825.45 (Average); C = 2.6
[Extreme right 50' of elevation 825 ≈ 825.45 included in here]

$$Q_2 = 2.6 \times 100 (H - 825.45)^{1.5} = 260 (H - 825.45)^{1.5}$$

③ Length = 3'
Invert = 823.61 (Av.)
C = 2.6

$$Q_3 = 2.6 \times 3 (H - 823.61)^{1.5} = 7.8 (H - 823.61)^{1.5}$$

④ Right Dam Length = 2'
Invert = 823.89 (Av)
C = 2.6

$$Q_4 = 2.6 \times 2 (H - 823.89)^{1.5} = 5.2 (H - 823.89)^{1.5}$$

⑤ Length = 122'
Invert = 825.72 (Av)
C = 2.6

$$Q_5 = 2.6 \times 122 (H - 825.72)^{1.5} = 317.2 (H - 825.72)^{1.5}$$

⑥ Length 108; Invert = 825.76 C = 2.6

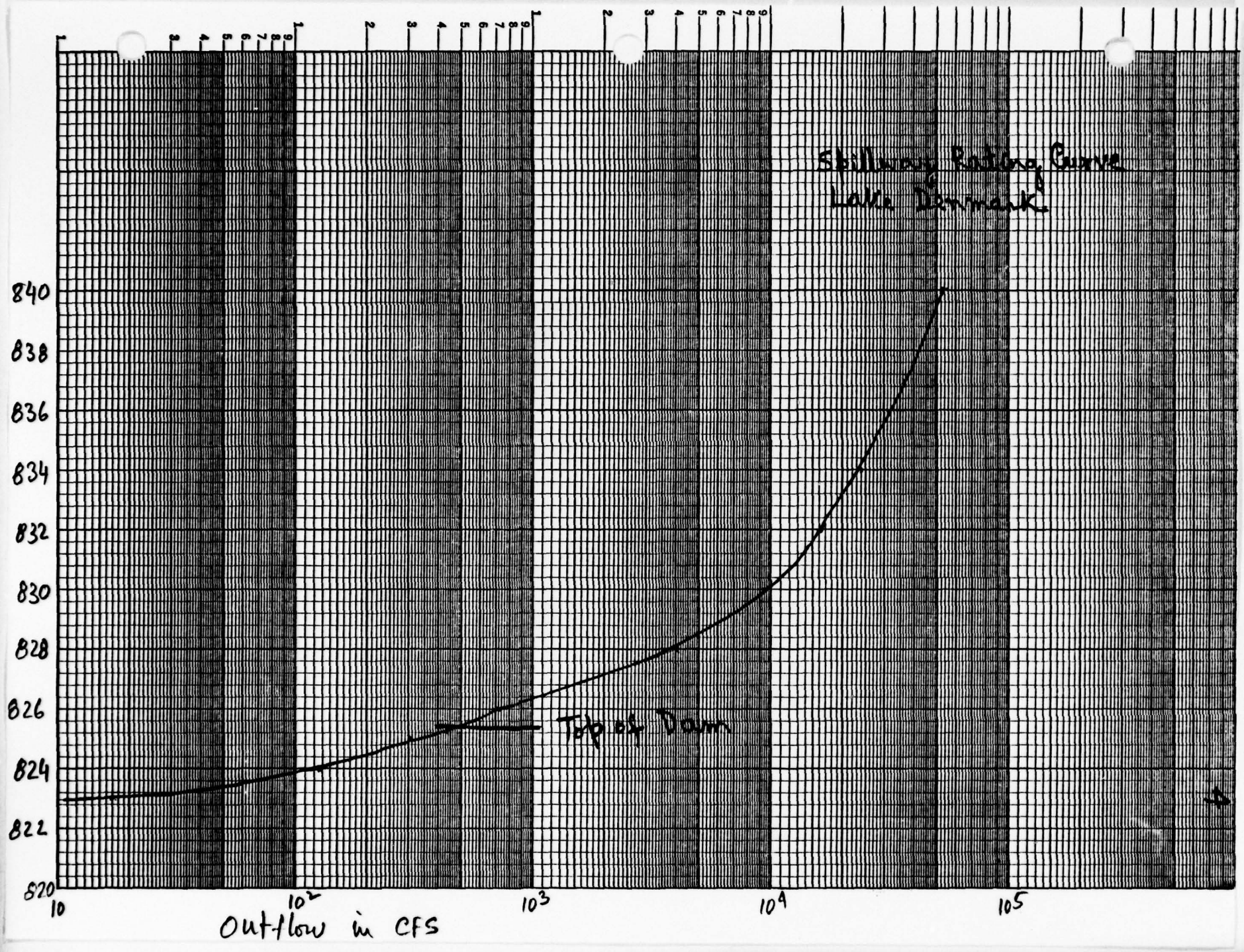
$$Q_6 = 2.6 \times 108 (H - 825.76)^{1.5} = 280.8 (H - 825.76)^{1.5}$$

FREDERIC R. HARRIS, INC.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection — Lake Denmark Dam
COMPUTED BY S.B. CHECKED BY
SHEET NO. 3 OF
JOB NO. 10-A44-02
DATE Aug. 1979

Rating Curve

W.S El H	Q_1 $(H-822.65)^{1.5}\times 79.5$	Q_2 $(H-825.45)^{1.5}\times 260$	Q_3 $(H-823.61)^{1.5}\times 7.8$	Q_4 $(H-823.89)^{1.5}\times 5.2$	Q_5 $(H-825.72)^{1.5}\times 317.2$	Q_6 $(H-825.76)^{1.5}\times 280.8$	Total
822.65	0						0
823	17						17
823.61	75		0				75
823.89	110		1.2	0			111
824	125		2	0			127
825	286		13	6			305
825.45	373	0	19	10			402 sb
825.72	428	36	24	13	0		501
825.76	436	45	25	13	3	0	522
826	487	106	29	16	47	33	718
828	984	1059	72	43	1092	941	4191
830	1584	2523	126	79	2809	2452	9573
832	2273	4358	190	120	4992	4377	16,310
834	3040	6500	261	167	7558	6642	24,168
837	4322	10,205	382	247	12,017	10,581	37,754
840	5745	14,430	518	336	17,117	15,089	53,235


Spillway Rating Curve
Lake Denmark
840
838
836
834
832
830
828
826
824
822
820
Top of Dam
10
10^2
10^3
10^4
10^5
Outflow in CFS

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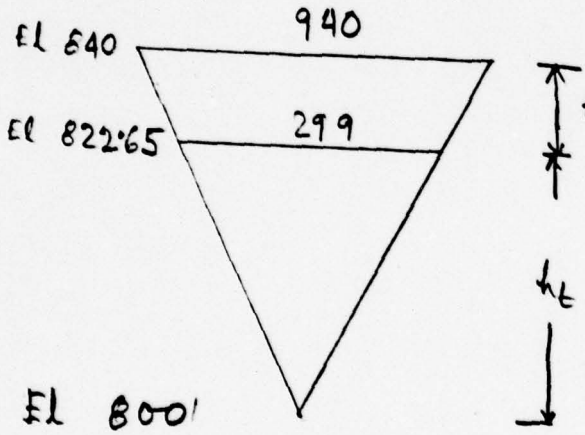
SUBJECT N.J. Dam Inspection — Lake Denmark Dam
SHEET NO. 5 OF
JOB NO. 10-A44-02
COMPUTED BY S.B CHECKED BY
DATE Aug. 1979

Reservoir Stage area relations

Elevation	Area Acres
800 *	0
Pool level	
822.65 (Pool level)	299 (USGS quad)
840	940 (USGS quad)

*



$$h_t = h \Big/ \left(\sqrt{\frac{A_2}{A_1}} - 1 \right) = 22.5$$

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SUBJECT N.J. Dam Inspection
Lake Denmark Dam
COMPUTED BY S.B. CHECKED BY

SHEET NO. 6 OF
JOB NO. 10-A44-03
DATE Aug. 1979

Determination of PMP

Probable Maximum Precipitation amount from HMS Report 33

= 22" (200 sq. miles - 24 hrs)
(The all season envelope)

Depth area duration relationship. Percentage to be applied to the above figure.

ZONE - 6

6 hr - 112 %
12 hr - 123 %
24 hr - 132 %
48 hr - 143 %

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SUBJECT N.J. Dam Inspection — Lake Denmark Dam
SHEET NO. 7 OF
JOB NO. 10-A44-62
COMPUTED BY S.B. CHECKED BY
DATE Aug. 1979

Estimation of Tc

1) Estimating Tc from velocity estimate and watercourse length

	Slope	Vel*	Remarks
Overland flow	$\frac{1160-1000}{2400} = 6.7\%$	3 Ft/sec	Pastures (Upper portion of watershed)
Reach 1	$\frac{1000-840}{7600} = 2.1\%$	1.5 Ft/sec	Natural Ch. (not well defined)
Reach 2	$\frac{840-824.83}{7600} = 0.2\%$	1 Ft/sec	Natural Ch.
Lake	7000 ft (Almost no slope)	—	Lake

$$Tc = \frac{2400}{3\times 3600} + \frac{7600}{1.5\times 3600} + \frac{7600}{1\times 3600}$$

$$= 3.74 \text{ hrs.}$$

2. Estimating Tc assuming same vel $S = 1.36\%$

$$Tc = \frac{24600}{1.5\times 3600} = 4.6 \text{ hrs.}$$

3. From Nomograph (S.C.S Guide) – same as Kirpich

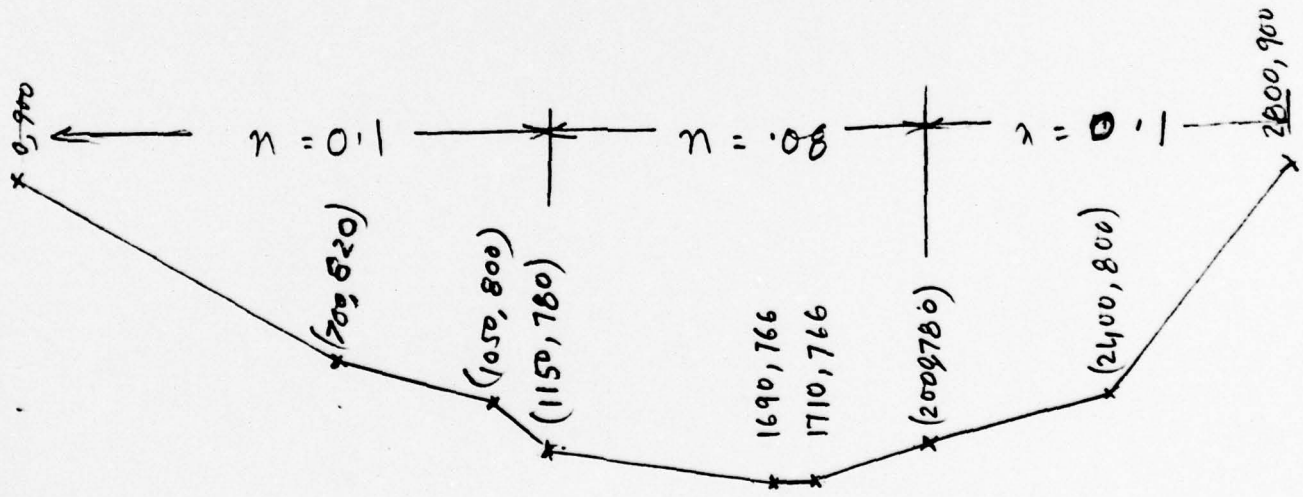
$$Tc = 1.5 \text{ hrs.}$$

Use T_c = 4.6 hrs

Lag = 0.6 T_c = 2.76 hrs.

Cross section at Downstream reach.
(At the confluence of Burnt Meadow Brook and Green Pond Brook)

At 1200 Ft D/S of Dam



Slope = 0.05

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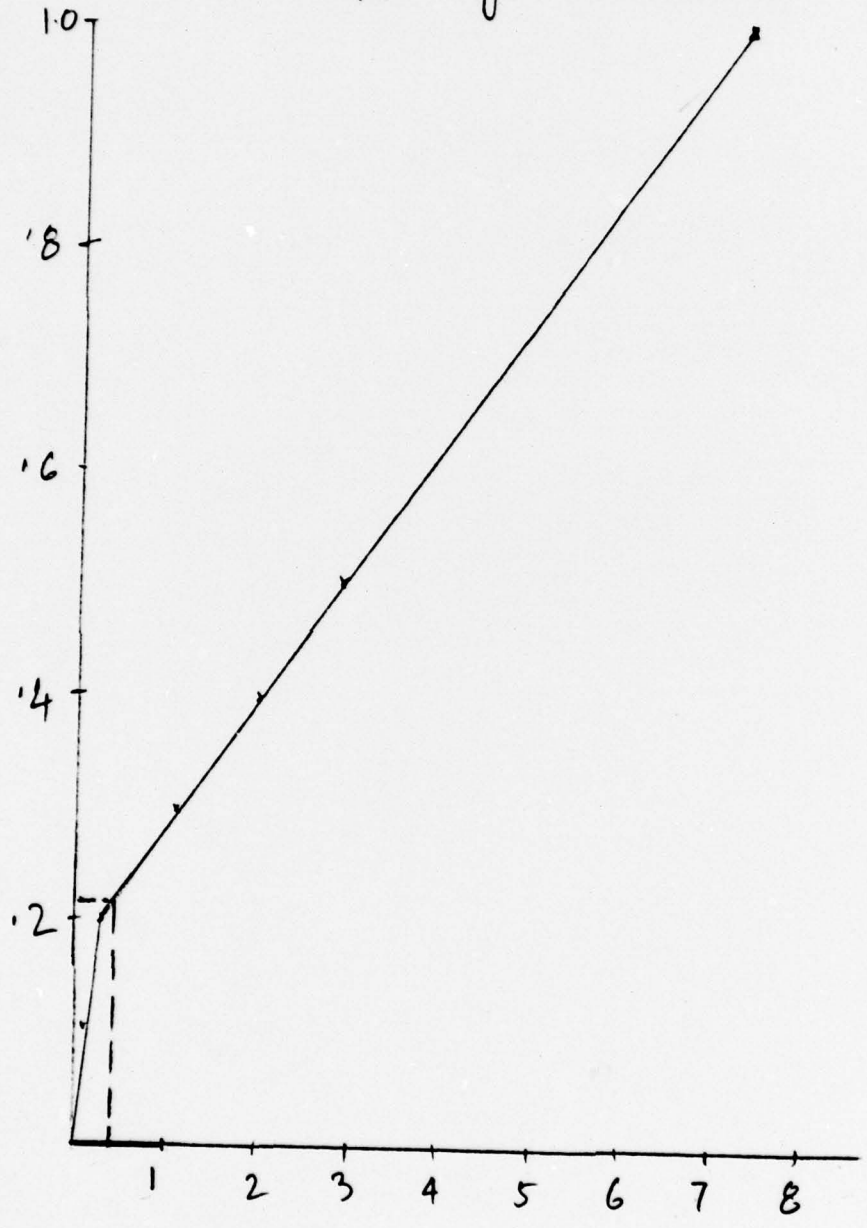
SUBJECT N.J. Dam Inspection
Lake Denmark

COMPUTED BY S.B CHECKED BY

SHEET NO. 8A OF
JOB NO. 10-A44-02
DATE Aug. 1979

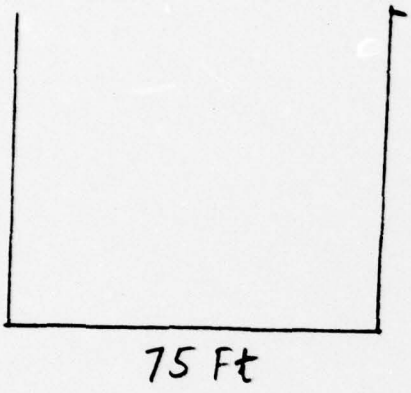
Overtopping Potential



Discharge in cfs. x 10³

The Dam will start overtopping at 22% of PMF (outflow = 402 cfs)

Breach Analysis



Effect of breach was analysed at 1200 ft downstream of Dam which is considered as the upper end of the hazard location

	At D/S Reach % PMF			
	100	50	40	30
W.S. El without Dam break	770.3	768.7	768.2	767.6
W.S. El with Dam break	772.2	772.1	772.0	771.8

At 100 % PMF (SDF) water level will rise ≈ 2' due to Dam break. Whereas at 30 % of PMF water level will rise about 4.2' due to Dam break.

According to the U.S.G.S. Quad sheet for Dover, several ammunition storage buildings are in danger from a stream elevation of 772' MSL. The "High" hazard potential is thus retained

Reservoir Evaluation

a) Discharge Vs Head

Low level outlet

① 2 Nos of 12" pipe

For One pipe

Area = $\frac{\pi}{4} \times 1^2 = 0.785$ sq ft

Length = 50 ft

Inlet invert = 818.05

Outlet invert = 817.05.

Assume tailwater depth = $\frac{2}{3}D$ = .67 ft above the invert

∴ Elevation = 818.05 + .67 ≈ 818.7

Entrance loss = $0.15 \frac{V^2}{2g}$

Exit loss = $1.0 \frac{V^2}{2g}$

Fr. loss Through pipe $\frac{n^2 L \times 2g}{(1.486)^2 \times (R)^{4/3}} \times \frac{V^2}{2g}$

$= \frac{(.014)^2 (50)(64.4)}{(1.486)^2 (.25)^{4/3}} \times \frac{V^2}{2g}$

$= 1.81 \frac{V^2}{2g}$

Loss through valve = $.2 \frac{V^2}{2g}$

Head loss = $3.16 \frac{V^2}{2g}$

$\therefore$ Head loss $= 3.16 \dfrac{Q^2}{29A^2}$ but $Q = \frac{Q}{2}$ in one pipe

$= 3.16 \times \dfrac{Q^2}{4 \times 29 \times (.785)^2}$

$= .02\,Q^2$

$Q = Cd \times A \sqrt{29(H - h_L)}$

$Q^2 = (.8)^2 \times (2 \times .785)^2 \times 29 \times (H - .02\,Q^2)$

$= 101.6\,H - 2\,Q^2$

or, $3Q^2 = 101.6\,H$

$Q = 5.82\sqrt{H}$

$= 5.82\sqrt{Z - 818.7}$

(2) 1 No of 24" pipe

Area $= \frac{\pi}{4} \times 2^2 = 3.14$ Sq ft

Length $= 65'$

Inlet invert 815.50
Outlet invert 814.50

Assume tailwater depth $= \frac{2}{3} D = 1.33$ ft above the invert.

$\therefore$ Elevation $= 814.5 + 1.33 = 815.8$

Entrance loss $= 0.15 \frac{v^2}{2g}$

Exit loss $= 1.0 \frac{v^2}{2g}$

loss through valve $= 0.2 \frac{v^2}{2g}$

Friction loss $= \frac{n^2 L \times 2g}{(1.486)^2 \times R^{4/3}} \times \frac{v^2}{2g}$

$= \frac{(.014)^2 \times 65 \times 64.4}{(1.486)^2 \times (.5)^{4/3}} \times \frac{v^2}{2g}$

$= .94 \frac{v^2}{2g}$

$\approx 2.3 \frac{v^2}{2g}$

$= \frac{2.3 Q^2}{2g A^2}$

$= .003 Q^2$

$Q = Cd \times A \times \sqrt{2g(H - hL)}$

$Q^2 = (.8)^2 \times (3.14)^2 \times 2g (H - .003 Q^2)$

$= 406 H - 1.22 Q^2$

$2.22 Q^2 = 406 H$

$1.Q = 13.5 \sqrt{Z - 815.8}$

Total low flow outlet =

$5.82 \sqrt{Z - 818.7} + 13.5 \sqrt{Z - 815.8}$

where Z = W.S.El

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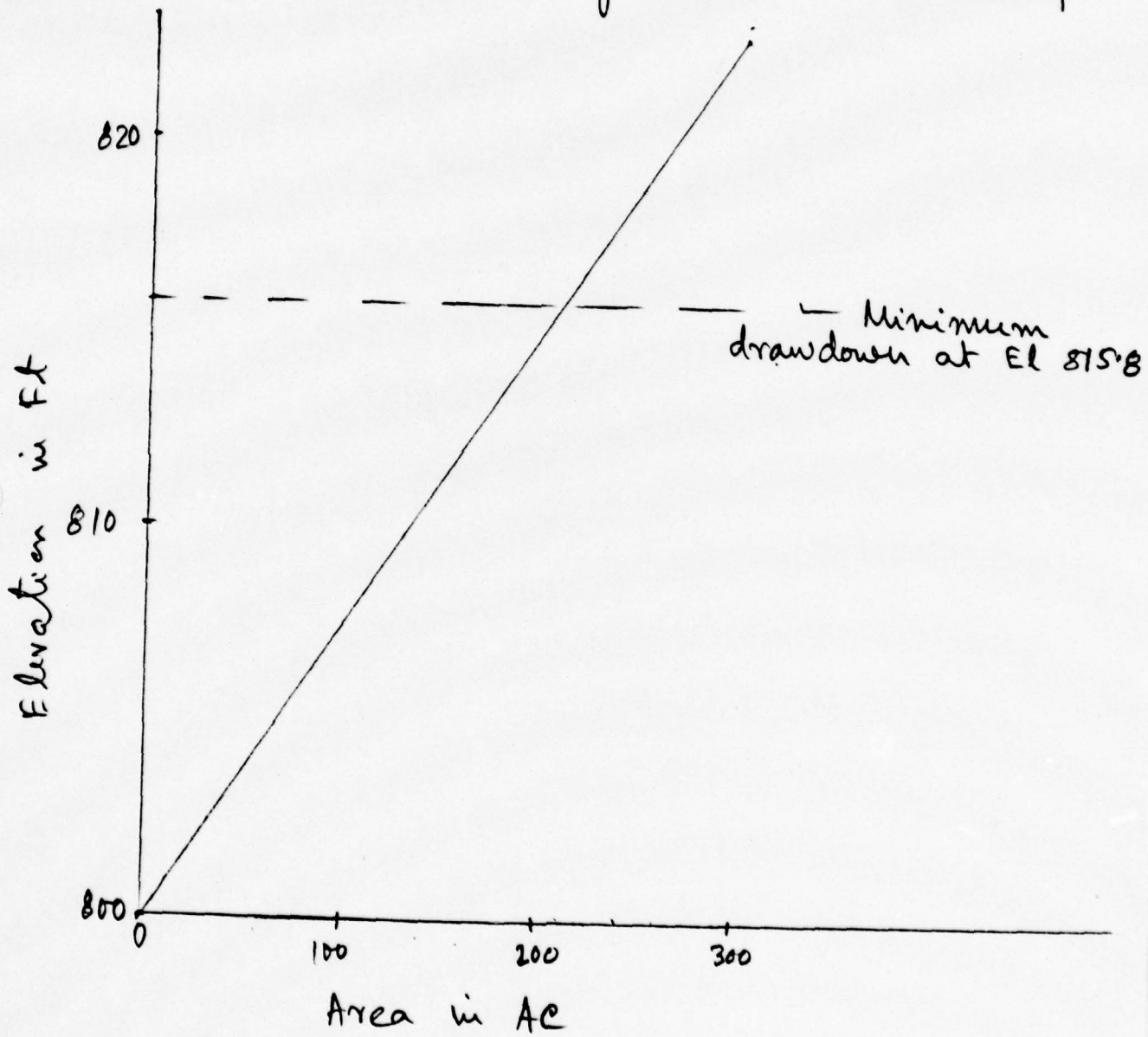
SUBJECT N.J. Dam Inspection
Lake Denmark

SHEET NO. 13 OF
JOB NO. 10-A44-02
COMPUTED BY S.B. CHECKED BY
DATE Aug., 1979

(b) Area vs. Head

Assume a straight line relationship



c) Drainage area = 4.5 sq miles
Assume Constant inflow = 2 cfs/sq mi
= 9 cfs.

El z	Area (Ac)	Av. Area (Ac)	Vol AF *	Q_1 $5.82\times\sqrt{z-818.7}$	Q_2 $13.5\times\sqrt{z-815.8}$	Outlet Q Q_1+Q_2	Time t draw-t $\frac{\text{Vol}\times 24}{1.98\times Q}$ (hrs)	Time t draw 9 cfs $\frac{9\times t_1}{Q}$ t_2 (hrs)	Total time t_1+t_2
822.65	299								
		296	192	11	34.5	46	51	10	61
822	292								
		286	286	9.7	32.2	42	83	18	101
821	280								
		272	272	7.8	29.3	37	89	22	111
820	265								
		258	335	4.7	25.4	30	135	40	175
818.7	250								
		245	172		21.6	22	95	39	134
818	240								
		232	232		17.6	18	156	78	234
817	225								
		217	260		10.5	11	287	235	522
815.8	210								
							896		1338

* The storage does not agree with the computed storage in Sec 1.3.(e), because different (linear) method used here*

Without any inflow time required for drawdown = 896 hrs ≈ 37 days

With a const inflow of 2 cfs/sq m, time reqd for drawdown = 1338 hrs ≈ 55 days

HEC1-DB

COMPUTER PRINT-OUT

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
    1                A1       N.J. DAM INSPECTION
    2                A2       LAKE DENMARK
    3                A3       MULTI RATIO PMF ROUTING
    4                B    150        0       30        0        0        0        0        0        0        0
    5                B1     5
    6                J      1        6        1
    7                J1   1.0       .5       .4       .3       .2       .1
    8                K        ORES.DEN                                          1
    9                K1       LOCAL INFLOW TO LAKE DENMARK
   10                M        1        2      4.5                4.5                                    1
   11                P        0       22      112      123      132      143
   12                T                                                        .1      .04                .01
   13                W2            2.76
   14                X       -1   -0.05        2
   15                K        1DAM.DEN
   16                K1       ROUTING THROUGH LAKE DENMARK
   17                Y                                 1        1
   18                Y1       1                                                -822.65      -1
   19                Y4822.65      823   823.61   823.89      824      825   825.45   825.72   825.76      826
   20                Y4   828      830      832      834      837      840
   21                Y5     0       17       75      111      127      305      402      501      522      718
   22                Y5  4191     9573    16310    24168    37754    53235
   23                $A     0      299      940
   24                $E   800   822.65      840
   25                $$822.65
   26                $D825.45
   27                K        1  REACH1                                            1
   28                K1       CHANNEL ROUTING MOD.PULS, UPTO CONFLUENCE
   29                Y                                 1        1
   30                Y1       1
   31                Y6      .1      .08       .1      766      800     1200      .05
   32                Y7       0      900     1050      800     1150      780     1690      766     1770      766
   33                Y7    2000      780     2400      800     2800      900
   34                K       99
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	S.DEN
ROUTE HYDROGRAPH TO	M.DEN
ROUTE HYDROGRAPH TO	REACH1
END OF NETWORK	

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********

RUN  DATE= 79/08/27.
     TIME= 10.07.35.


                    N.J. DAM INSPECTION
                    LAKE DENMARK
                    MULTI RATIO PMF ROUTING

                                JOB SPECIFICATION
          NQ      NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT    NSTAN
         150        0       30        0       0        0        0        0        0        0
                                    JOPER      NWT   LROPT   TRACE
                                        5        0       0       0


                              MULTI-PLAN ANALYSES TO BE PERFORMED
                                  NPLAN= 1 NRTIO= 6 LRTIO= 1
                RTIOS=   1.00     .50     .40     .30     .20     .10

**********      **********      **********      **********      **********

                              SUB-AREA RUNOFF COMPUTATION

                LOCAL INFLOW TO LAKE DENMARK

                          ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                         S.DEN       0       0       0       0       0       1       0       0

                                HYDROGRAPH DATA
              IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                  1       2    4.50    0.00    4.50    0.00   0.000       0       1       0

                                  PRECIP DATA
                         SPFE     PMS      R6     R12     R24     R48     R72     R96
                         0.00   22.00  112.00  123.00  132.00  143.00    0.00    0.00
TRSPC COMPUTED BY THE PROGRAM IS  .800

                                  LOSS DATA
            LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                0    0.00    0.00    1.00    0.00    0.00    1.00     .10     .04    0.00     .01

                              UNIT HYDROGRAPH DATA
                          TC=  0.00    LAG=  2.76

                                RECESSION DATA
                          STRTQ=   -1.00    QRCSN=    -.05    RTIOR= 2.00

          UNIT HYDROGRAPH 30 END OF PERIOD ORDINATES, TC=    0.00 HOURS, LAG=   2.76  VOL= 1.00
          55.     165.     338.     551.     685.     722.     688.     605.     495.     360.
         270.     205.     160.     122.      93.      71.      54.      41.      31.      24.
          18.      14.      11.       8.       7.       5.       4.       3.       1.       0.

       0                          END-OF-PERIOD FLOW
     MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS     COMP Q     MO.DA  HR.MN  PERIOD   RAIN   EXCS   LOSS     COMP Q

     1.01    .30       1    .00    .00    .00         4.      1.02  14.00      76   1.18   1.16    .02      1755.
```

1.01	1.00	2	.00	.00	.00	4.
1.01	1.30	3	.00	.00	.00	4.
1.01	2.00	4	.00	.00	.00	3.
1.01	2.30	5	.00	.00	.00	3.
1.01	3.00	6	.00	.00	.00	3.
1.01	3.30	7	.00	.00	.00	3.
1.01	4.00	8	.00	.00	.00	3.
1.01	4.30	9	.00	.00	.00	3.
1.01	5.00	10	.00	.00	.00	2.
1.01	5.30	11	.00	.00	.00	2.
1.01	6.00	12	.00	.00	.00	2.
1.01	6.30	13	.01	.00	.01	2.
1.01	7.00	14	.01	.00	.01	2.
1.01	7.30	15	.01	.00	.01	2.
1.01	8.00	16	.01	.00	.01	2.
1.01	8.30	17	.01	.00	.01	2.
1.01	9.00	18	.01	.00	.01	2.
1.01	9.30	19	.01	.00	.01	2.
1.01	10.00	20	.01	.00	.01	2.
1.01	10.30	21	.01	.00	.01	2.
1.01	11.00	22	.01	.00	.01	2.
1.01	11.30	23	.01	.00	.01	2.
1.01	12.00	24	.01	.00	.01	2.
1.01	12.30	25	.08	.06	.02	5.
1.01	13.00	26	.08	.06	.02	15.
1.01	13.30	27	.10	.08	.02	37.
1.01	14.00	28	.10	.08	.02	74.
1.01	14.30	29	.12	.10	.02	123.
1.01	15.00	30	.12	.10	.02	181.
1.01	15.30	31	.15	.13	.02	245.
1.01	16.00	32	.47	.45	.02	331.
1.01	16.30	33	.11	.10	.02	432.
1.01	17.00	34	.11	.10	.02	547.
1.01	17.30	35	.09	.07	.02	664.
1.01	18.00	36	.09	.07	.02	736.
1.01	18.30	37	.01	.00	.01	757.
1.01	19.00	38	.01	.00	.01	732.
1.01	19.30	39	.01	.00	.01	668.
1.01	20.00	40	.01	.00	.01	576.
1.01	20.30	41	.01	.00	.01	466.
1.01	21.00	42	.01	.00	.01	370.
1.01	21.30	43	.01	.00	.01	288.
1.01	22.00	44	.01	.00	.01	223.
1.01	22.30	45	.01	.00	.01	169.
1.01	23.00	46	.01	.00	.01	128.
1.01	23.30	47	.01	.00	.01	98.
1.02	0.00	48	.01	.00	.01	75.
1.02	.30	49	.05	.03	.02	59.
1.02	1.00	50	.05	.03	.02	51.
1.02	1.30	51	.05	.03	.02	52.
1.02	2.00	52	.05	.03	.02	62.
1.02	2.30	53	.05	.03	.02	79.
1.02	3.00	54	.05	.03	.02	98.
1.02	3.30	55	.05	.03	.02	117.
1.02	4.00	56	.05	.03	.02	134.
1.02	4.30	57	.05	.03	.02	149.
1.02	5.00	58	.05	.03	.02	159.
1.02	5.30	59	.05	.03	.02	166.
1.02	6.00	60	.05	.03	.02	172.
1.02	6.30	61	.16	.14	.02	182.
1.02	7.00	62	.16	.14	.02	203.
1.02	7.30	63	.16	.14	.02	243.
1.02	8.00	64	.16	.14	.02	305.
1.02	8.30	65	.16	.14	.02	381.
1.02	9.00	66	.16	.14	.02	461.
1.02	9.30	67	.16	.14	.02	536.
1.02	14.30	77	1.48	1.46	.02	2409.
1.02	15.00	78	1.48	1.46	.02	3166.
1.02	15.30	79	1.80	1.78	.02	3989.
1.02	16.00	80	5.69	5.67	.02	5062.
1.02	16.30	81	1.38	1.36	.02	6324.
1.02	17.00	82	1.38	1.36	.02	7734.
1.02	17.30	83	1.08	1.06	.02	9152.
1.02	18.00	84	1.08	1.06	.02	10044.
1.02	18.30	85	.08	.06	.02	10298.
1.02	19.00	86	.08	.06	.02	9976.
1.02	19.30	87	.08	.06	.02	9168.
1.02	20.00	88	.08	.06	.02	7979.
1.02	20.30	89	.08	.06	.02	6553.
1.02	21.00	90	.08	.06	.02	5295.
1.02	21.30	91	.08	.06	.02	4205.
1.02	22.00	92	.08	.06	.02	3320.
1.02	22.30	93	.08	.06	.02	2596.
1.02	23.00	94	.08	.06	.02	2058.
1.02	23.30	95	.08	.06	.02	1654.
1.03	0.00	96	.08	.06	.02	1345.
1.03	.30	97	0.00	0.00	0.00	1102.
1.03	1.00	98	0.00	0.00	0.00	913.
1.03	1.30	99	0.00	0.00	0.00	756.
1.03	2.00	100	0.00	0.00	0.00	618.
1.03	2.30	101	0.00	0.00	0.00	510.
1.03	3.00	102	0.00	0.00	0.00	475.
1.03	3.30	103	0.00	0.00	0.00	444.
1.03	4.00	104	0.00	0.00	0.00	414.
1.03	4.30	105	0.00	0.00	0.00	386.
1.03	5.00	106	0.00	0.00	0.00	360.
1.03	5.30	107	0.00	0.00	0.00	336.
1.03	6.00	108	0.00	0.00	0.00	314.
1.03	6.30	109	0.00	0.00	0.00	293.
1.03	7.00	110	0.00	0.00	0.00	273.
1.03	7.30	111	0.00	0.00	0.00	255.
1.03	8.00	112	0.00	0.00	0.00	238.
1.03	8.30	113	0.00	0.00	0.00	222.
1.03	9.00	114	0.00	0.00	0.00	207.
1.03	9.30	115	0.00	0.00	0.00	193.
1.03	10.00	116	0.00	0.00	0.00	180.
1.03	10.30	117	0.00	0.00	0.00	168.
1.03	11.00	118	0.00	0.00	0.00	157.
1.03	11.30	119	0.00	0.00	0.00	146.
1.03	12.00	120	0.00	0.00	0.00	137.
1.03	12.30	121	0.00	0.00	0.00	127.
1.03	13.00	122	0.00	0.00	0.00	119.
1.03	13.30	123	0.00	0.00	0.00	111.
1.03	14.00	124	0.00	0.00	0.00	103.
1.03	14.30	125	0.00	0.00	0.00	97.
1.03	15.00	126	0.00	0.00	0.00	90.
1.03	15.30	127	0.00	0.00	0.00	84.
1.03	16.00	128	0.00	0.00	0.00	78.
1.03	16.30	129	0.00	0.00	0.00	73.
1.03	17.00	130	0.00	0.00	0.00	68.
1.03	17.30	131	0.00	0.00	0.00	64.
1.03	18.00	132	0.00	0.00	0.00	59.
1.03	18.30	133	0.00	0.00	0.00	55.
1.03	19.00	134	0.00	0.00	0.00	52.
1.03	19.30	135	0.00	0.00	0.00	48.
1.03	20.00	136	0.00	0.00	0.00	45.
1.03	20.30	137	0.00	0.00	0.00	42.
1.03	21.00	138	0.00	0.00	0.00	39.
1.03	21.30	139	0.00	0.00	0.00	37.
1.03	22.00	140	0.00	0.00	0.00	34.
1.03	22.30	141	0.00	0.00	0.00	32.
1.03	23.00	142	0.00	0.00	0.00	30.

1.02	10.30	69	.16	.14	.02	657.	1.04	0.00	144	0.00	0.00	0.00	26.
1.02	11.00	70	.16	.14	.02	697.	1.04	.30	145	0.00	0.00	0.00	24.
1.02	11.30	71	.16	.14	.02	726.	1.04	1.00	146	0.00	0.00	0.00	23.
1.02	12.00	72	.16	.14	.02	749.	1.04	1.30	147	0.00	0.00	0.00	21.
1.02	12.30	73	.99	.97	.02	812.	1.04	2.00	148	0.00	0.00	0.00	20.
1.02	13.00	74	.99	.97	.02	961.	1.04	2.30	149	0.00	0.00	0.00	18.
1.02	13.30	75	1.18	1.16	.02	1261.	1.04	3.00	150	0.00	0.00	0.00	17.
									SUM	25.17	23.69	1.48	142918.
										(639.)	(602.)	(38.)	(4046.99)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10298.	7640.	2701.	992.	142907.
CMS	292.	216.	76.	28.	4047.
INCHES		15.79	22.34	24.61	24.62
MM		401.15	567.38	625.21	625.29
AC-FT		3788.	5358.	5904.	5905.
THOUS CU M		4673.	6609.	7283.	7284.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS					
				RATIO 1 1.00	RATIO 2 .50	RATIO 3 .40	RATIO 4 .30	RATIO 5 .20	RATIO 6 .10
HYDROGRAPH AT	S.DEN	4.50	1	10298.	5149.	4119.	3090.	2060.	1030.
		(11.65)		(291.62)(	145.81)(	116.65)(	87.49)(	58.32)(	29.16)(
ROUTED TO	M.DEN	4.50	1	7349.	2872.	2008.	1048.	372.	147.
		(11.65)		(208.11)(	81.32)(	56.85)(	29.66)(	10.52)(	4.15)(
ROUTED TO	REACH1	4.50	1	7361.	2886.	2007.	1046.	372.	147.
		(11.65)		(208.45)(	81.72)(	56.83)(	29.63)(	10.53)(	4.15)(

SUMMARY OF DAM S. ..TY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	822.65	822.65	825.45
STORAGE	2257.	2257.	3203.
OUTFLOW	0.	0.	402.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	829.17	3.72	4830.	7349.	22.50	44.00	0.00
.50	827.24	1.79	3930.	2872.	17.50	45.00	0.00
.40	826.74	1.29	3718.	2008.	15.00	45.00	0.00
.30	826.19	.74	3492.	1048.	12.00	46.00	0.00
.20	825.31	0.00	3150.	372.	0.00	47.00	0.00
.10	824.11	0.00	2723.	147.	0.00	48.00	0.00

PLAN 1 STATION REACH1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	7361.	770.3	44.00
.50	2886.	768.7	45.00
.40	2007.	768.2	45.00
.30	1046.	767.6	46.00
.20	372.	766.6	47.50
.10	147.	766.2	48.00

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FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
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A1       N.J. DAM INSPECTION
A2       LAKE DENMARK
A3       MULTYPLAN DAM FAILURE ANALYSIS
B    150                 30                                                  3
B1     5
J      1         4         1
J1   1.        .5        .4        .3
K      OHES.DEN                                                 1
K1       LOCAL INFLOW TO LAKE DENMARK
M      1         2       4.5                 4.5                           1
P      0        22       112       123       132       143
T                                                        .1       .04                .01
*2             2.76
A     -1     -0.05         2
K      IDAM.DEN
K1       ROUTING THROUGH LAKE DENMARK
Y                                          1         1
Y1     1                                                      -822.65        -1
Y4822.65       823    823.61    823.89       824       825    825.45    825.72    825.76       826
Y4   828       830       832       834       837       840
Y5     0        17        75       111       127       305       402       501       522       718
Y5  4191      9573     16310     24168     37754     53235
$A     0       299       940
$E   800    822.65       840
$$822.65
$U825.45
$B    75         0       810        .5   822.65    826.1
K      1  REACH1                                                   1
K1       CHANNEL ROUTING MOD.PULS. UPTO CONFLUENCE
Y                                          1         1
Y1     1
Y6    .1       .08        .1       766       800      1200       .05
Y7     0       900      1050       800      1150       780      1690       766      1770       766
Y7  2000       780      2400       800      2800       900
K     99
A
A
A
A
A
```

PREVIEW OF SEQUENCE OF STREAM NETWORK CALCULATIONS

RUNOFF HYDROGRAPH AT	S.DEN
ROUTE HYDROGRAPH TO	M.DEN
ROUTE HYDROGRAPH TO	REACH1
END OF NETWORK	

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

RUN DATE= 79/06/28.
TIME= 15.12.26.

N.J. DAM INSPECTION
LAKE DENMARK
MULTYPLAN DAM FAILURE ANALYSIS

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	MSTAN
150	0	30	0	0	0	0	0	3	0

JOPER	NEST	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 4 LRTIO= 1
RTIOS= 1.00 .50 .40 .30

****

SUB-AREA RUNOFF COMPUTATION

LOCAL INFLOW TO LAKE DENMARK

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
S.DEN	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	4.50	0.00	4.50	0.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	22.00	112.00	123.00	132.00	143.00	0.00	0.00

TRSPC COMPUTED BY THE PROGRAM IS .800

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	.10	.04	0.00	.01

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 2.76

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

UNIT HYDROGRAPH 30 END OF PERIOD ORDINATES, TC= 0.00 HOURS, LAG= 2.76 VOL= 1.00

55.	165.	338.	551.	685.	722.	688.	605.	495.	360.
270.	205.	160.	122.	93.	71.	54.	41.	31.	24.
18.	14.	11.	8.	7.	5.	4.	3.	1.	0.

END-OF-PERIOD FLOW

0 MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.30	1	.00	.00	.00	4.	1.02	14.00	76	1.18	1.16	.02	1755.

1.01	1.00	2	.00	.00	.00	4.	1.02	14.30	77	1.48	1.46	.02	3166.
1.01	1.30	3	.00	.00	.00	4.	1.02	15.00	78	1.48	1.46	.02	3166.
1.01	2.00	4	.00	.00	.00	3.	1.02	15.30	79	1.80	1.78	.02	3989.
1.01	2.30	5	.00	.00	.00	3.	1.02	16.00	80	5.69	5.67	.02	5062.
1.01	3.00	6	.00	.00	.00	3.	1.02	16.30	81	1.38	1.36	.02	6324.
1.01	3.30	7	.00	.00	.00	3.	1.02	17.00	82	1.38	1.36	.02	7734.
1.01	4.00	8	.00	.00	.00	3.	1.02	17.30	83	1.08	1.06	.02	9152.
1.01	4.30	9	.00	.00	.00	3.	1.02	18.00	84	1.08	1.06	.02	10044.
1.01	5.00	10	.00	.00	.00	2.	1.02	18.30	85	.08	.06	.02	10298.
1.01	5.30	11	.00	.00	.00	2.	1.02	19.00	86	.08	.06	.02	9976.
1.01	6.00	12	.00	.00	.00	2.	1.02	19.30	87	.08	.06	.02	9168.
1.01	6.30	13	.01	.00	.01	2.	1.02	20.00	88	.08	.06	.02	7979.
1.01	7.00	14	.01	.00	.01	2.	1.02	20.30	89	.08	.06	.02	6553.
1.01	7.30	15	.01	.00	.01	2.	1.02	21.00	90	.08	.06	.02	5295.
1.01	8.00	16	.01	.00	.01	2.	1.02	21.30	91	.08	.06	.02	4205.
1.01	8.30	17	.01	.00	.01	2.	1.02	22.00	92	.08	.06	.02	3320.
1.01	9.00	18	.01	.00	.01	2.	1.02	22.30	93	.08	.06	.02	2596.
1.01	9.30	19	.01	.00	.01	2.	1.02	23.00	94	.08	.06	.02	2058.
1.01	10.00	20	.01	.00	.01	2.	1.02	23.30	95	.08	.06	.02	1654.
1.01	10.30	21	.01	.00	.01	2.	1.03	0.00	96	.08	.06	.02	1345.
1.01	11.00	22	.01	.00	.01	2.	1.03	.30	97	0.00	0.00	0.00	1102.
1.01	11.30	23	.01	.00	.01	2.	1.03	1.00	98	0.00	0.00	0.00	913.
1.01	12.00	24	.01	.00	.01	2.	1.03	1.30	99	0.00	0.00	0.00	756.
1.01	12.30	25	.08	.06	.02	5.	1.03	2.00	100	0.00	0.00	0.00	618.
1.01	13.00	26	.08	.06	.02	15.	1.03	2.30	101	0.00	0.00	0.00	510.
1.01	13.30	27	.10	.08	.02	37.	1.03	3.00	102	0.00	0.00	0.00	475.
1.01	14.00	28	.10	.08	.02	74.	1.03	3.30	103	0.00	0.00	0.00	444.
1.01	14.30	29	.12	.10	.02	123.	1.03	4.00	104	0.00	0.00	0.00	414.
1.01	15.00	30	.12	.10	.02	181.	1.03	4.30	105	0.00	0.00	0.00	386.
1.01	15.30	31	.15	.13	.02	245.	1.03	5.00	106	0.00	0.00	0.00	360.
1.01	16.00	32	.47	.45	.02	331.	1.03	5.30	107	0.00	0.00	0.00	336.
1.01	16.30	33	.11	.10	.02	432.	1.03	6.00	108	0.00	0.00	0.00	314.
1.01	17.00	34	.11	.10	.02	547.	1.03	6.30	109	0.00	0.00	0.00	293.
1.01	17.30	35	.09	.07	.02	664.	1.03	7.00	110	0.00	0.00	0.00	273.
1.01	18.00	36	.09	.07	.02	736.	1.03	7.30	111	0.00	0.00	0.00	255.
1.01	18.30	37	.01	.00	.01	757.	1.03	8.00	112	0.00	0.00	0.00	238.
1.01	19.00	38	.01	.00	.01	732.	1.03	8.30	113	0.00	0.00	0.00	222.
1.01	19.30	39	.01	.00	.01	668.	1.03	9.00	114	0.00	0.00	0.00	207.
1.01	20.00	40	.01	.00	.01	576.	1.03	9.30	115	0.00	0.00	0.00	193.
1.01	20.30	41	.01	.00	.01	466.	1.03	10.00	116	0.00	0.00	0.00	180.
1.01	21.00	42	.01	.00	.01	370.	1.03	10.30	117	0.00	0.00	0.00	168.
1.01	21.30	43	.01	.00	.01	288.	1.03	11.00	118	0.00	0.00	0.00	157.
1.01	22.00	44	.01	.00	.01	223.	1.03	11.30	119	0.00	0.00	0.00	146.
1.01	22.30	45	.01	.00	.01	169.	1.03	12.00	120	0.00	0.00	0.00	137.
1.01	23.00	46	.01	.00	.01	128.	1.03	12.30	121	0.00	0.00	0.00	127.
1.01	23.30	47	.01	.00	.01	98.	1.03	13.00	122	0.00	0.00	0.00	119.
1.02	0.00	48	.01	.00	.01	75.	1.03	13.30	123	0.00	0.00	0.00	111.
1.02	.30	49	.05	.03	.02	59.	1.03	14.00	124	0.00	0.00	0.00	103.
1.02	1.00	50	.05	.03	.02	51.	1.03	14.30	125	0.00	0.00	0.00	97.
1.02	1.30	51	.05	.03	.02	52.	1.03	15.00	126	0.00	0.00	0.00	90.
1.02	2.00	52	.05	.03	.02	62.	1.03	15.30	127	0.00	0.00	0.00	84.
1.02	2.30	53	.05	.03	.02	79.	1.03	16.00	128	0.00	0.00	0.00	78.
1.02	3.00	54	.05	.03	.02	98.	1.03	16.30	129	0.00	0.00	0.00	73.
1.02	3.30	55	.05	.03	.02	117.	1.03	17.00	130	0.00	0.00	0.00	68.
1.02	4.00	56	.05	.03	.02	134.	1.03	17.30	131	0.00	0.00	0.00	64.
1.02	4.30	57	.05	.03	.02	149.	1.03	18.00	132	0.00	0.00	0.00	59.
1.02	5.00	58	.05	.03	.02	159.	1.03	18.30	133	0.00	0.00	0.00	55.
1.02	5.30	59	.05	.03	.02	166.	1.03	19.00	134	0.00	0.00	0.00	52.
1.02	6.00	60	.05	.03	.02	172.	1.03	19.30	135	0.00	0.00	0.00	48.
1.02	6.30	61	.16	.14	.02	182.	1.03	20.00	136	0.00	0.00	0.00	45.
1.02	7.00	62	.16	.14	.02	203.	1.03	20.30	137	0.00	0.00	0.00	42.
1.02	7.30	63	.16	.14	.02	243.	1.03	21.00	138	0.00	0.00	0.00	39.
1.02	8.00	64	.16	.14	.02	305.	1.03	21.30	139	0.00	0.00	0.00	37.
1.02	8.30	65	.16	.14	.02	381.	1.03	22.00	140	0.00	0.00	0.00	34.
1.02	9.00	66	.16	.14	.02	461.	1.03	22.30	141	0.00	0.00	0.00	32.
1.02	9.30	67	.16	.14	.02	536.	1.03	23.00	142	0.00	0.00	0.00	30.

1.02	10.00	68	.16	.14	.02	603.	1.03	23.30	143	0.00	0.00	0.00		28.
1.02	10.30	69	.16	.14	.02	657.	1.04	0.00	144	0.00	0.00	0.00		26.
1.02	11.00	70	.16	.14	.02	697.	1.04	.30	145	0.00	0.00	0.00		24.
1.02	11.30	71	.16	.14	.02	726.	1.04	1.00	146	0.00	0.00	0.00		23.
1.02	12.00	72	.16	.14	.02	749.	1.04	1.30	147	0.00	0.00	0.00		21.
1.02	12.30	73	.99	.97	.02	812.	1.04	2.00	148	0.00	0.00	0.00		20.
1.02	13.00	74	.99	.97	.02	961.	1.04	2.30	149	0.00	0.00	0.00		18.
1.02	13.30	75	1.18	1.16	.02	1261.	1.04	3.00	150	0.00	0.00	0.00		17.
									SUM	25.17	23.69	1.48		142918.
										(639.)	(602.)	(38.)		(4046.99)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	10298.	7640.	2701.	992.	142907.
CMS	292.	216.	76.	28.	4047.
INCHES		15.79	22.34	24.61	24.62
MM		401.15	567.38	625.21	625.29
AC-FT		3788.	5358.	5904.	5905.
THOUS CU M		4673.	6609.	7283.	7284.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS			
				RATIO 1	RATIO 2	RATIO 3	RATIO 4
				1.00	.50	.40	.30
HYDROGRAPH AT	S.DEN	4.50	1	10298.	5149.	4119.	3090.
		(11.65)		(291.62)(	145.81)(	116.65)(	87.49)(
ROUTED TO	M.DEN	4.50	1	16316.	15842.	15067.	14631.
		(11.65)		(462.03)(	448.60)(	426.64)(	414.32)(
ROUTED TO	REACH1	4.50	1	15999.	15198.	14591.	13913.
		(11.65)		(453.04)(	430.36)(	413.17)(	393.97)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	822.65	822.65	825.45
STORAGE	2257.	2257.	3203.
OUTFLOW	0.	0.	402.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	826.49	1.04	3612.	16316.	2.00	41.00	40.50
.50	826.46	1.01	3601.	15842.	2.30	43.00	42.50
.40	826.19	.74	3493.	15067.	1.64	43.50	43.00
.30	826.14	.69	3471.	14631.	2.54	45.50	45.00

PLAN 1 STATION REACH1

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
1.00	15999.	772.2	41.50
.50	15198.	772.1	43.50
.40	14591.	772.0	44.00
.30	13913.	771.8	46.00